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Monitoring Report On The Upper Ottawa Street Landfill Site 1982-1984

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MONITORING PROGRAM REPORT
UPPER OTTAWA STREET LANDFILL SITE
1982 - 1984 FOR
THE REGIONAL MUNICIPALITY OF
HAMILTON-WENTWORTH

DRAFT

DISCUSSION

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DECEMBER, 1984

Gartner Lee
Associates Limited

Gartner Lee Associates Limited

Consulting Engineering
Geolologists
Biologists and
Hydrogeologists

Toronto-Buttonville Airport ■ Markham,Ontario ■ L3P 3J9 ■ 416-477-8400
Telex-06-986278

December 20, 1984

Regional Municipality of Hamilton-Wentworth,
Department of Engineering,
71 Main Street West,
Hamilton, Ontario.
L8N 3T4.

Attention: Mr. J.R.G. Leach, P.Eng.
Commissioner of Engineering

Dear Sirs:

Re: Monitoring Program, 1982-1984
Upper Ottawa Street Landfill Site
For 83-115

We respectfully submit our draft report to document the results of the monitoring progoram which has been undertaken jointly by the Region and Gartner Lee Associates Limited at the Upper Ottawa Street Landfill Site between 1982 to 1984.

The report presents and evaluates the results of surface water, ground water, bottom sediment, flood plain and gas monitoring at this site. Recommendations for continued monitoring are also presented.

Once we have received the Region review comments, the report will be finalized and forwarded to the Region.

Yours very truly
GARTNER LEE ASSOCIATES LIMITED

P.K. Lee, M.A.Sc., P.Eng.
Consulting Engineering Geologist

PKL:dg

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1.0 INTRODUCTION:

This report documents the results of the monitoring program which has been carried out jointly by the Region and Gartner Lee Associates Limited (GLAL) at the Upper Ottawa Street Landfill Site, Hamilton, between 1982 and 1984. The hydrogeological setting of the landfill site is described in two previous reports by GLAL (reports 78-119 and 79-78). A monitoring program was initiated by the Region in 1980 and a report was prepared by GLAL to document the findings of that study (report 80-190, dated March 31, 1983).

Additional hydrogeological studies were commissioned by the Upper Ottawa Street Landfill Site Committee to be carried out in parallel with, but independent from, those programs undertaken by the Region. These additional studies have been very detailed in their scope and have mainly focussed on the identification of specific chemical parameters which are present in the ground water and which may be attributable solely to a source within the landfill. The reader is referred to those reports issued by the Committee for further details of their studies.

The work program reported herein was undertaken by the Region and GLAL as a result of the recommendations presented in our previous monitoring report, 80-190. Unlike the detailed studies commissioned by the Committee, the intent of this program is to provide a more

encompassing overview assessment of the effect of the landfill site, in terms of not only ground water aspects but also for surface water quality, and combustible gas hazard. The study area involved lands adjacent to the landfill and extended as far as the Albion Falls area.

1.2 STUDY PROGRAM:

The study program consisted of the following items:

A. By the Region:

(i) The collection and chemical analysis of surface water samples from Redhill Creek at six periods; November 1981, June and December 1982, June and November 1983 and May 1984. Samples were taken at three stations SW1, SW4, and SW7. Samples were collected from station SW2 in November, 1981, June and December 1982 only. Also included was the collection of a leachate sample from the manhole designated MH1. The locations of the sampling stations are shown on Figure 1 in Appendix 4.

(ii) The collection of stream bottom sediment samples at two stations, designated SW1 and SW4 in June 1982 and November 1983 which were used for P.C.B. analysis. Sediment samples were not collected from station SW2.

(iii) The collection of ground water samples at the same times stated in (i) above, from the following six monitor locations:

Borehole 1 - Monitor I (Bedrock)
Borehole 4 - Monitor I (Bedrock)
Borehole 6 - Monitor I (Bedrock)
Borehole 9 - Monitor I (Bedrock)
Borehole 11 - Monitor I (Bedrock)
Borehole 12 - Monitor I (Bedrock)

B. By Gartner Lee

(i) To undertake streamflow measurements at four stations along Redhill Creek and at one station in the tributary to Redhill Creek, designated as SG1 to SG5 inclusive in Figure 1. The measurements were to be carried out in November 1983 and May 1984 to coincide with the surface water sampling program.

(ii) To carry out a mass balance calculation analysis based on the results of the streamflow measurements and surface water chemistry analyses.

(iii) To carry out an inspection of the Redhill Creek floodplain lands and the Escarpment Face at Albion Falls in November 1983 and May 1984. The intent of the inspections was to identify the presence

of leachate springs, if present, in the floodplain lands. Gartner Lee staff were accompanied during both inspections by a representative from the Upper Ottawa Street Landfill Site Committee.

(iv) To prepare a report to document the results of the entire monitoring program undertaken by both the Region and Gartner Lee.

2.0 SUMMARY OF RESULTS:

A summary and discussion of the highlights of the results of the monitoring program is presented in this section. An in-depth discussion and details of the work and results is presented in Section 5.0 at the end of the report.

2.1 SURFACE WATER CONSIDERATIONS:

The surface water chemistry data and streamflow gauging results which have been obtained during the monitoring program do not provide a definitive detailed effect, that can be attributed to the landfill site, on the water quality in Redhill Creek. Mass balance calculations to assess the magnitude of the chemical loading from the landfill cannot be determined with a high degree of accuracy during the high flow periods.

In terms of the chemical concentration of specific parameters within Redhill Creek water at the time of sampling, the following general comments are provided. A limited amount of data are available until December 1982 at station SW2, located immediately downstream from the landfill. However, our review shows that for all the parameters measured, the concentrations were consistently higher at SW2 compared to the monitor station upstream from the landfill, at station SW4. Further downstream at station SW1, for which data are available until May 1984, the concentrations of iron, ammonia and TKN (except May 1984) are elevated above upstream values. The concentration of other parameters, however, such as conductivity,

chloride, phenol and BOD at the downstream stations is sometimes less than, and sometimes greater than, the upstream location.

Thus, whereas it is apparent that the water quality in Redhill Creek is generally poorer below the landfill site, compared to upstream from the landfill, it is not possible at this time to assign total responsibility to the landfill. Two items work to confuse the issue:

a) the periodic and erratic frequency of chemical or sediment loading to Redhill Creek from upstream of the landfill site. As noted in Section 5.2, the sediment load in Redhill Creek can increase dramatically, in a very short period, for example during the hours of the monitoring day, due to discharge into the creek from upstream. Such flash discharges could affect the reliability of the chemical analyses. It would appear that the significance of daily changes compared to seasonal monitoring are almost impossible to put into context.

b) No data are available regarding the chemical quality of the water entering Redhill Creek from the tributary which joins the creek a short distance below SW2.

In order to better define long-term trends in water quality we have suggested that additional monitoring in Redhill Creek and its tributary should be undertaken.

A monitoring program is suggested in Section 3.1. A comparison of complete data base for any one monitor period may be more reliable than that of season to season.

2.2 REDHILL CREEK SEDIMENT:

The results of the PCB analyses on sediment samples from Redhill Creek continue to indicate that a source of PCBs exists upstream from the landfill site. The data also suggest that some degree of additional source of PCBs may be present within the landfill as indicated by the increased concentration of PCB in the sediment at the downstream station SW1 in November 1983. PCBs have been detected in past studies both in the interior of the landfill (Borehole 2 location) and in the leachate obtained from manhole MH1. Additional monitoring is suggested in Section 3.1.

2.3 GROUND WATER CONSIDERATIONS:

The results of the ground water monitoring program confirm that leachate originating within the landfill site is continuing to migrate away from the fills in the bedrock ground water flow system. The effect of the leachate on the ground water quality is, in part, masked by the natural poor quality and variability of the ground water due to the underlying Rochester shale beds. The ground water quality at boreholes 9 and 11 certainly appears to be degraded compared to the natural background quality in terms of conductivity and chloride and also TKN at borehole 9. Also, the concentration of the parameters measured appears to be increasing with time.

Additional monitoring of ground water quality is required in order to establish long term trends. A program is suggested in Section 3.2.

2.4 REDHILL CREEK FLOODPLAIN INSPECTION:

The conditions which were observed within the floodplain lands during the November 1983 and May 1984 inspections were essentially similar to those previously documented in earlier reports. The detailed inspection along the northern limit of the landfill revealed several leachate seeps discharging directly into Redhill Creek. The majority of the seeps were located immediately above the concrete protection mat on the face of the landfill. Seeps were also observed at various elevations on the landfill face beyond the western limit of the concrete mat. We have suggested that remedial action be taken along these sections to present the seepage from discharging directly into Redhill Creek.

2.5 COMBUSTIBLE GAS:

Combustible gas has been detected in potentially explosive concentrations in the Quonset hut on three occasions in 1982-1983. Gas has been detected in gas monitor GM3 on one occasion in February 1984. It is suggested that monitoring continue at these two locations on a monthly basis through the coming winter to the spring of 1985. The results should then be assessed and the need for continued monitoring can be re-evaluated at that time.

3.0 MONITORING PROGRAM:

The following monitoring program is recommended for 1985:

3.1 SURFACE WATER AND SEDIMENT:

Samples of surface water should be obtained from both Redhill Creek and its tributary in May (high flow conditions) and August-September (low flow conditions). The stations to be sampled are SW1, SW2, SW4, SW7 and the tributary immediately upstream from the junction with Redhill Creek. The parameters to be considered for analysis are conductivity, pH, chlorides, total Kjeldahl nitrogen, iron, ammonia, phenol, BOD and PCB.

Loading calculations should be done only in summer periods (during periods of sustained low flow, i.e. with no major storm events preceding monitoring) to properly put the concentrations measured into proper perspective. It is of vital importance that accurate flows be measured at each sample station at the same time as samples are taken. However, in wet periods the erratic and flash flow nature of the basin make such measurements inaccurate. Therefore gauging should not be done at those times.

Sediment samples should be obtained on the same day as surface water samples are collected and analysed for PCB content. The stations to be sampled are SW1, SW2, SW4 and the tributary sediment immediately upstream from Redhill Creek.

3.2 GROUND WATER:

A ground water monitoring program which is similar to that carried out previously should be continued in 1985. Ground water samples should be obtained from the bedrock monitors at boreholes 1, 6, 9, 11 and 12. Parameters to be analysed should be the same as those listed in Table 5, Appendix 2. Sampling should be carried out on the same day as the surface water sampling program. It is very important that the ground water monitors be properly developed prior to sampling. We suggest that a minimum of 2 wellbore volumes of water should be removed from each monitor prior to sampling. To facilitate this development, consideration could be given to the use of a compressed nitrogen airlift system and dedicated tubing at each monitor location.

3.3 COMBUSTIBLE GAS:

Monitoring for combustible gas should be continued on a monthly basis through the coming winter until spring 1985 at the Quonset Hut and gas monitor GM3. The results should be evaluated in the spring of 1985 to assess the need for continued monitoring through the remainder of 1985.

4.0 RECOMMENDATIONS:

The following recommendations are submitted:

- A surface water, ground water and gas monitoring program should be carried out in accordance with the details provided in Sections 3.1, 3.2 and 3.3 of this report.

- Remedial action should be taken along the upper portion of the concrete retaining face of the northern boundary of the landfill to prevent the leachate seeps from entering Redhill Creek.

- The results of the monitoring program and remedial action should be evaluated by a qualified hydrogeologist and documented in a yearly report.

5.0 DETAILED STUDY FINDINGS:

The detailed results from the various component sections of the monitoring program are provided in the technical appendices at the back of the report. The results from each section are presented below:

5.1 SURFACE WATER

5.1.1 CHEMISTRY RESULTS

The results of the chemistry analyses, carried out on surface water samples between November 1981 to May 1984. are presented in Table 1, in Appendix 1. Table 2 presents the results of the chemistry analyses on leachate samples from manhole MH1 over the same time period.

Figures 2 to 6 present graphically the change in concentration with time for specific parameters between 1979 to 1984 (as available), at the four surface water stations and for leachate from manhole MH1. The parameters presented are Conductivity (umhos/cm), Chloride (mg/L), Total Kjeldahl Nitrogen -TKN (mg/L) and Phenol (ug/L).

Figure 2 presents these data for station SW4 which is located on Redhill Creek, upstream from the landfill site. This is regarded as background surface water quality, and as such, it is the base against which the surface water adjacent to, and downstream from the landfill, is compared.

The conductivity has remained relatively stable since late 1982 at between 800 to 1000 umhos/cm and has actually showed an apparent general decrease. The chloride content appears to follow the reverse trend, in as much as the concentration has fluctuated to a greater degree and has incresed slightly since 1981, from a value of 85mg/L to 118 mg/L in May 1984. It should be noted however, that both the chloride content and conductivity reached a peak value in May 1981 (395 mg/L and 2110 umhos/cm). The values have consistently declined and have been lower since that time.

The TKN concentration has decreased since the initial monitoring in 1979 and since 1982 the value has remained below 1 mg/L. The exception to this is the most recent sample, that of May 1984, when a value of 2.48 mg/L was reported.

The Phenol concentration has fluctuated more than any other parameter and has varied quite substantially ranging from a value below the detection limit to 15 ug/L in June 1983.

Figure 3 presents the chemistry data for leachate obtained from manhole MH1. These data are presented here to illustrate the relative strength or concentration of the leachate within the landfill. The conductivity has varied from a high of 15000 uhos/cm in 1982 to a low of 7500 uhos/cm in November 1983. The leachate has exhibited an apparent trend of decreasing conductivity

with time. All of the other three parameters (Cl, TKN and phenol) showed marked decreases in the study period. The chloride concentration was consistently about 3000 mg/L from late 1982 until May 1984 when the value dropped to 1750 mg/L. The concentration of TKN has exhibited large fluctuations from 540 mg/L in June 1982 to 11.2 mg/L in May 1984. The concentration of phenol also appears to be following a decreasing trend, dropping from a value of 281 ug/L in 1982 to 1.38 ug/L in November 1983.

Figure 4 presents the chemistry data from Station SW2 which is located on Redhill Creek adjacent to the railroad bridge at the eastern boundary of the landfill site. The data set is incomplete as the surface water has not been sampled at this location since December 1982. During the time period for which data are available, the conductivity and Phenol concentration was essentially similar to Station SW4 (see Fig. 2). Both the chloride and TKN concentrations at SW2 were consistently elevated above the values at SW4.

Figure 5 presents the chemistry data from station SW1 located on Redhill Creek immediately upstream from the pond which is adjacent to Albion Falls. The conductivity of the creek at this station has remained relatively stable and is similar to that measured at SW4. The chloride concentration has exhibited a similar trend to that observed at SW4. Between 1980 and 1982 the actual value was slightly lower at SW1. In 1983 the value was slightly higher at SW1 and then lower in May 1984. The concentration of TKN has been greater at SW1 than SW4, although the

trend of decreasing value with time is similar. TKN was not detected at SW1 in May 1984. With regard to the Phenol concentration at SW1, both the trend and the actual values are similar to those observed at SW4. Phenol was not detected in 1984, whereas a value of 19 ug/L was reported in June 1983.

Figure 6 presents the chemistry data obtained from SW7 which is located on Redhill Creek at Albion Falls. This data set is very limited as sampling was carried out only in June 1982 and May 1984. Both the conductivity and chloride values were similar at SW7 and SW4 in May 1984 (900 umhos/cm conductivity at both stations and chloride values of 112 mg/L at SW7 and 118 mg/L at SW4). The concentration of TKN was higher at SW7 in 1982 (4.4 mg/L whereas it was slightly lower than SW4 in 1984 (0.52 mg/L). Phenol has not been detected at SW7 at the times of sampling.

5.1.2 STREAMFLOW GAUGING RESULTS

A summary of the results of the streamflow gauging exercise is presented together with the individual data sheets in Appendix 1. It is important to note that the maximum accuracy which can reasonably be attained in gauging a streamflow in its natural channel is between 5 to 10%. In the situation present at this site, it is not possible to detect the effect of the landfill on Redhill Creek in terms of increase in quantity of flow.

The results obtained in May 1984 provide the highest degree of correlation between the flow measurements taken in Redhill Creek and its tributary compared to the estimate of flow over Albion Falls (182 L/sec in creek, 127 L/sec in tributary, 340 L/sec estimated flow over falls). The streamflow gaugings which were carried out in the concrete channel section at SG1 encountered problems on both occasions, and the values obtained are not considered representative of the actual streamflow (the error being on the high side).

In summary, the streamflow gauging results indicate the following items:

(a) the streamflow in Redhill Creek adjacent to the landfill was in the order of 180 L/sec.

(b) the streamflow in the tributary creek was about 130 L/sec.

(c) the water flow over Albion Falls via the weir was about 340 L/sec.

With regard to the Mass Balance analysis which was to have been carried out, a combination of factors render the analysis to be questionable. The limitations to these analyses are:

(i) Surface water samples have not been collected at station SW2 since December 1982. Since this station

is located on Redhill Creek at the downstream section of the landfill, it is not possible to evaluate the effect on surface water quality of leachate entering the creek at the landfill.

(ii) In order to evaluate the chemical loading input to Redhill Creek from the tributary, it would be necessary to sample and analyse that water chemically at the time the streamflow gaugings were carried out. This has not been done.

(iii) The streamflow gaugings carried out at SG1, which is located on Redhill Creek downstream from the landfill and the tributary, showed unrealistically high values. As a consequence it is not possible to accurately quantify the possible effect of leachate input to Redhill Creek via groundwater discharge to the creek between the landfill and the gauging station SG1.

(iv) The surface water at Albion Falls was not sampled and analysed in November 1983. Also, the estimate of flow over the falls via the weir in November 1983 is an estimate and cannot be measured with accuracy.

5.2 REDHILL CREEK SEDIMENT:

The results of the P.C.B. analyses which have been carried out on samples of the bottom sediment from stations SW1, SW2 and SW4 are presented in Table 3, Appendix 1. Trace ammounts of PCBs were identified in the sediment at SW4 and SW1 in June 1982 and November 1983. Testing was not carried out at station SW2 on either of these occasions. In the 1982 sampling, the concentrations in the sediment were similar both upstream (SW4) and downstream (SW1) from the landfill. In the November 1983 sampling, the concentration downstream from the landfill was approximately twice as high as that reported for upstream at SW4 (0.034 ug/g at SW1, 0.018 ug/g at SW4).

As indicated in our previous monitoring report, GLAL 80-190, the presence of PCBs in the creek sediment upstream from the landfill indicates that a source of PCBs exists somewhere upstream. The increase in PCB concentration in the sediment downstream from the landfill at SW1 may indicate additional contribution from the landfill or a flux through the whole system (upstream from the fill). The evidence at this time is not conclusive.

It should also be noted that during the streamflow gauging in May 1984, the sediment load in Redhill Creek increased dramatically during the site visit. In fact, the sediment load became great enough to impart a creamy colouration to the water. The increase in sediment load was apparent

in the creek upstream from the landfill site, indicating an external (upstream) source. The sediment load and colouration also decreased as rapidly as it had increased.

5.3 REDHILL CREEK FLOOD PLAIN INSPECTION:

On November 30, 1983 and May 10, 1984, Mr. Hims carried out a detailed inspection of the Escarpment lands which form the Redhill Creek valley walls and floodplain area east (downstream) of the landfill site. Mr. Hims was accompanied during parts of the inspection by Mr. J. Barbash on November 30, 1983, and by Mrs. A. Beaufrey on May 10, 1984, both of whom were present as representatives of the Upper Ottawa Street Landfill Site Committee.

The areas of interest are identified on Figure 1 by the same designation as was used in our previous monitoring report. Details are as follows:

November 30, 1983 — May 10, 1984

Area A
(Albion Falls)

The spring, designated A, is a small seepage area about 3 m below Mountain Road on the south side of the falls.

Flow was not discernible at the rock contact. Small patches of iron-red staining were evident. Water was ponding in the grassed area immediately below the spring. Surface run-off from a road culvert may also contribute to this ponding. Conductivity of water was 2950 umhos/cm. No odour was noted. Conductivity of surface water flowing over falls was 1250 umhos/cm.

Seepage was evident at the rock face 1 L/min. The rock was discoloured iron brown and a slight oily film was evident on the water surface. Clear water with no odour was discharging from the culvert.

Area B

No springs nor seepages were evident along this section of Redhill Creek during both inspections.

Area C

Location C is the concrete channel lining associated with a buried sewer pipe crossing. Streamflow gauging SW1 was carried out at this location.

A dark brown and green staining and seepage (± 1 L/mm) was present about half way up the channel lining on the south side. A pool of standing water was present behind the north side of the concrete lining. The water had an oily film on the surface and the conductivity was 3250 umhos/cm. Creek water conductivity was 1350 umhos/cm. An odour of hydrogen sulphide was present at this location.

Similar conditions were observed at location during this inspection except that the oily film was not present on the pool of water.

Areas C to D

No seepages nor springs were noted along this section of the creek. At the concrete outfall structure, water was discharging into Redhill Creek at a rate of about 4 L/min. The conductivity was 1650 umhos/cm. The conductivity of the creek upstream was 1400 umhos/cm.

Several small seepages were noted in the floodplain through this section. The water was clear with no odour. The largest seepage area was at location K just above the floodplain. The seepage formed a small stream which discharged into Redhill Creek. The water was clear with no odour. A small slope failure was evident immediately downstream from the concrete outfall structure. Slight seepage was evident on the failure surface.

Areas E to H

These areas are located along the tributary to Redhill Creek.

No seeps nor springs were noted. The conductivity of the tributary water was between 1125 to 1200 mhos/cm. The conductivity of the Creek upstream from the tributary was 1350 mhos/cm.

The sediment loading in the tributary was substantially greater than in Redhill Creek.

One spring was noted at location G on the east bank of the tributary. Some brown staining was evident on the ground surface and the water had an oily sheen on the surface. No odour was present.

Occasional pondings of standing water were present on the landfill side. The water varied from clear to slightly murky. No odour was present.

Areas I and J

These are surface water ponds adjacent to the valley walls. The water was generally clear, odourless and the conductivity ranged from 700-800 umhos/cm.

Similar conditions were observed during this inspection. The area around Borehole 9 was also wet at this time. The water was clear and odourless. Some channelization was apparent and algal growth was apparent within the channels.

Redhill Creek Adjacent to Landfill

Streamflow gauging SG2 was carried out just upstream from the railroad bridge. The conductivity of the creek water was 1525 umhos/cm. A general inspection was carried out along this section of the creek up to the concrete stilling structure. Several small (<1 L/min) discoloured seepages were observed at various locations and elevations on the concrete retaining face of the landfill. The seepages discharged directly into the creek. Gas was noted venting in portions of the creek bed. Discoloured and odourous seepages were also noted in the faces of

A more detailed inspection was carried out along this section of the creek during this visit. The locations are noted on Figure 1.

Location 1 at toe of landfill site. A small discharge of black-green liquid was present from the culvert (± 6 L/min) into the creek.

Location 2 - No seepages nor staining noted in toe protection.

Location 3 - Small discoloured seepage present at the top of the concrete protection.

the landfill at several locations at the north end where there was no concrete retaining faces. The conductivity of the creek water at the north end was 2100 umhos/cm. The conductivity of the creek water at streamflow gauging station SG3, opposite the landfill, was 2400 umhos/cm.

Location 4 - Occasional seepages present in concrete protection. Gas venting through Creek bed.

Location 5 - Discoloured seepage area present at top of concrete protection. Dark coloured liquid seeping into creek (<1 L/min).

Location 6 - Occasional seeps and/or stained areas noted.

Location 7 - Discoloured seepage area was present about 15 m long at top of the protection. Liquid is brown and oily and gas was venting through the fills. Seepage was entering the creek ($\pm$ 1 L/min).

Location 8 - Occasional small seepages or discolourations present.

Location 9 - The concrete protection has bulged at the toe of this location. Seepage out of the fills was occurring above the protection and gas venting was also noted. A scummy brown liquid was seeping into the creek (<1 L/min).

Location 10 - No seepage noted along this section.

Location 11 - Occasional small seepages were noted along this section.

Location 12 - Occasional small seepages were noted at the top of the concrete protection along this section.

Location 13 - The concrete protection ends at this location.

Location 14 - Seepage and soil erosion from the face was observed at this location. The toe of the fills had bulged into the creek bed and was being actively eroded.

Location 15 - At the streamflow gauging station SG3 - No seepages present.

Location 16 - A small seepage was present at the toe of the slope and red brown staining was present. Erosion of the surface soils had occurred at this location with subsequent gully formation down the face of the fills.

Location 17 - No seepages noted in this area.

Location 18 - Occasional seepages were present at the toe of the slope. The liquid had an oily sheen and red brown staining of the ground surface had occurred.

Location 19 - Small discoloured seepages were present at the toe of the slope in this location. Also some surface erosion and gullying had occurred.

5.4 GROUND WATER:

The borehole logs for those groundwater monitors which were sampled are included for reference in Appendix 2. The details of the groundwater monitors are presented in Table 4. All the bedrock monitors are screened in the dolomite rock formation.

Table 5 in Appendix 2 presents the chemistry analysis results which have been obtained between November 1981 and May 1984 from groundwater samples from the bedrock monitors in boreholes 1, 4, 6, 9, 11 and 12, Figures 7 to 12 graphically present the chemical concentration versus time for these monitors. The parameters illustrated are Conductivity (umhos/cm) Chloride (mg/L), Total Kjeldahl Nitrogen, TKN, (mg/L) and Phenol (ug/L), as per the surface water stations.

Figures 7 and 8 present these data for the bedrock monitors in boreholes 1 and 12, both of which are located upgradient from the landfill site. As stated in our previous monitoring report, 80-190, the ground water quality from these two monitors is poor due to probable influences from the Rochester shale which underlies the Lockport Dolomite. The bedrock ground water from borehole 1, upgradient in the flow, in particular has exhibited substantial natural fluctuations (orders of magnitude) in chemical content since 1981. The conductivity and chloride concentration in this monitor in May 1984 were 11000 umhos/cm and 4050 mg/L respectively. The corresponding values for Borehole 12 were 1700 umhos/cm and 500 mg/L. The phenol and TKN concentrations in both monitors have varied between values in the 10-100+ range in 1981-1982 (ug/L phenol and mg/L TKN) down to below the detectable limit in 1983 and 1984.

A P P E N D I X

APPENDIX 1 - SURFACE WATER

Table 1 Surface Water Chemistry results (Nov 1981 to May 1984).

Table 2 Leachate Chemistry Results From Manhole M#1 (Nov.1981 to May 1984).

Table 3 Results of PCB Analysis on Sediment Sample (Oct. 1979 to Nov. 1983).

Summary of Streamflow Gaugings

Streamflow Gauging Records SG1 -SG5 Nov.30,1983

SG1 -SG5 May 10,1984

PROJECT 83-115

TABLE 1 SHEET 1

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW1 TESTED BY Collected and Tested by Region

PARAMETER \ DATE	Nov.26 1981	June 3 1982	Dec.8 1982	June 7 1983	Nov.11 1983	May 10 1984					
Conductivity(umhos/cm)	1050	1780	900	1020	750	850					
pH	7.5	8.04	7.6	7.65	7.4	7.7					
Chlorides	95.5	22	94	110	185	108					
tot.Kjeldahl Nitrogen	5.2	3.4	0.32	1.24	0.44	not Detect.					
Iron	0.6	-	0.44	0.17	0.49	0.20					
Ammonia	2.4	2.1	<0.1	0.24	0.44	0.34					
Phenol (ug/L)	3.5	1.5	not Detect	19	0.04	0					
BOD	5.6	4.5	2.7	not Detect	13	5					

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115 TABLE 1 SHEET 2

WATER ANALYSIS RESULTS

SAMPLING LOCATION Surface Water Station SW2 TESTED BY Collected and Tested by Region

PARAMETER \ DATE	Nov 26 1981	June 3 1982	Dec 8 1982								
Conductivity(umhos/cm)	1200	1550	1050								
pH	7.7	8.17	8.0								
Chlorides	125	205	115								
tot.Kjeldahl Nitrogen	3.0	3.4	0.4								
Iron	<0.1	-	0.10								
BOD	5.1	3.0	2.7								
Ammonia	2.4	1.9	<0.1								
Phenol(ug/l)	25	0	not Detect								

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115

TABLE 1 SHEET 3

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW4 TESTED BY Collected and Tested by Region

Date / PARAMETER	Nov 26 1981	June 3 1982	Dec 8 1982	June 7 1983	Nov 11 1983	May 10 1984					
Conductivity(umhos/cm)	1050	1400	1000	910	800	900					
pH	7.6	8.6	7.7	7.4	7.5	7.5					
Chlorides	85	65	95	92	155	118					
tot.Kjeldahl Nitrogen	0.8	0.4	<0.10	<1.0	0	2.48					
Iron	0.2	-	<0.10	0.10	0.24	0.13					
BOD	4.6	-	2.2	2	13	50					
Ammonia	0.35	0.1	<0.1	<0.1	0.07	0.18					
Phenol (ug/L)	14	0	not Detect	15	0.04	0					

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115

TABLE 1 SHEET 4

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW7 TESTED BY COLLECTED AND TESTED BY REGION

Date / PARAMETER	Nov 26 1981	June 3 1982	Dec 8 1982	June 7 1983	Nov 11 1983	May 10 1984					
Conductivity(umhos/cm)		1520				900					
pH		8•22				7.6					
Chlorides		19				112					
tot.Kjeldahl Nitrogen		44				0.52					
Iron		-				0.15					
BOD		2.0				40					
Ammonia		2.1				0.32					
Phenol (ug/L)		0				0					

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115 TABLE 2 SHEET 1

WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 REMARKS COLLECTION AND ANALYSIS BY REGION

PROPERTY		Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984					
CONDUCTIVITY μMHOS/CM.		10,000	15000	15000	10900	7500	9000					
pH		7.55	8.29	7.6	8.1	7.9	8.1					
HARDNESS ($Ca CO_3$)		1250	-	1275	1300	1080	1270					
ALKALINITY ($Ca CO_3$)												
CHLORIDES (Cl)		60	75	3000	28.50	3150	1750					
SULPHATES (SO_4)		300	225	5200	160	600	100					
PHOSPHOROUS AS P	Total	2.0	6.8	2.5	4.29	3.5	2.8					
	Soluble											
NITROGEN (N)	Total Kjeldahl	1200	6.43	396	540	95	11.2					
	Free Ammonia	1200	643	340	360	132.5	0.02					
	Nitrite ug/L	-	-	-	1.0	ND	2.9					
	Nitrate	-	-	7.3	1.6	-	-					
METALS	Chromium (Cr)	ND	ND	0.50	0.11	0.10	ND					
	Copper (Cu)	0.1	0.1	0.33	0.40	ND	0.04					
	Zinc (Zn)	0.1	0.2	0.28	0.11	0.16	0.10					
	Nickel (Ni)	0.3	0.3	0.24	0.23	0.17	0.12					
	Iron (Fe)	1.5	2.7	7.7	4.2	4.5	7.2					
BOD		286	696	129	119	620	560					
Total Dissolved Solids		8736	-	10108	9282	6640	6140					
COD		2132	4706	1801	96	956	941					

NOTE: concentrations in p.p.m. unless otherwise noted.

PROJECT 83-115

TABLE 2 SHEET 2

WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 TESTED BY REGION

	Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984					
Dissolved Oxygen	801	-	4.5	7.1	-	2.6					
Phenol ug/L	331	156	281	80	1.38	-					
P.C.B. ug/L	2.1	3.0	-	-	<0.004	-					
Total Coliform/100ml	5000±	800	1800	2500	-	-					
Fecal Coliform/100ml	10	100	0	45	-	-					

NOTE: concentrations in p.p.m unless otherwise noted.

TABLE 3: P.C.B. IN SEDIMENT SAMPLE

		Oct.31 1979	Nov. 25 1980	June 3 1982	Nov.30 1983	
STATION	SW 1	No Test	0.017	0.025	0.034	
	SW 2	244	0.90	No Test	No Test	
	SW 4	662	0.39	0.024	0.018	
Soil At Borehole 2		No Test	No Test	No Test	0.023	

NOTES:

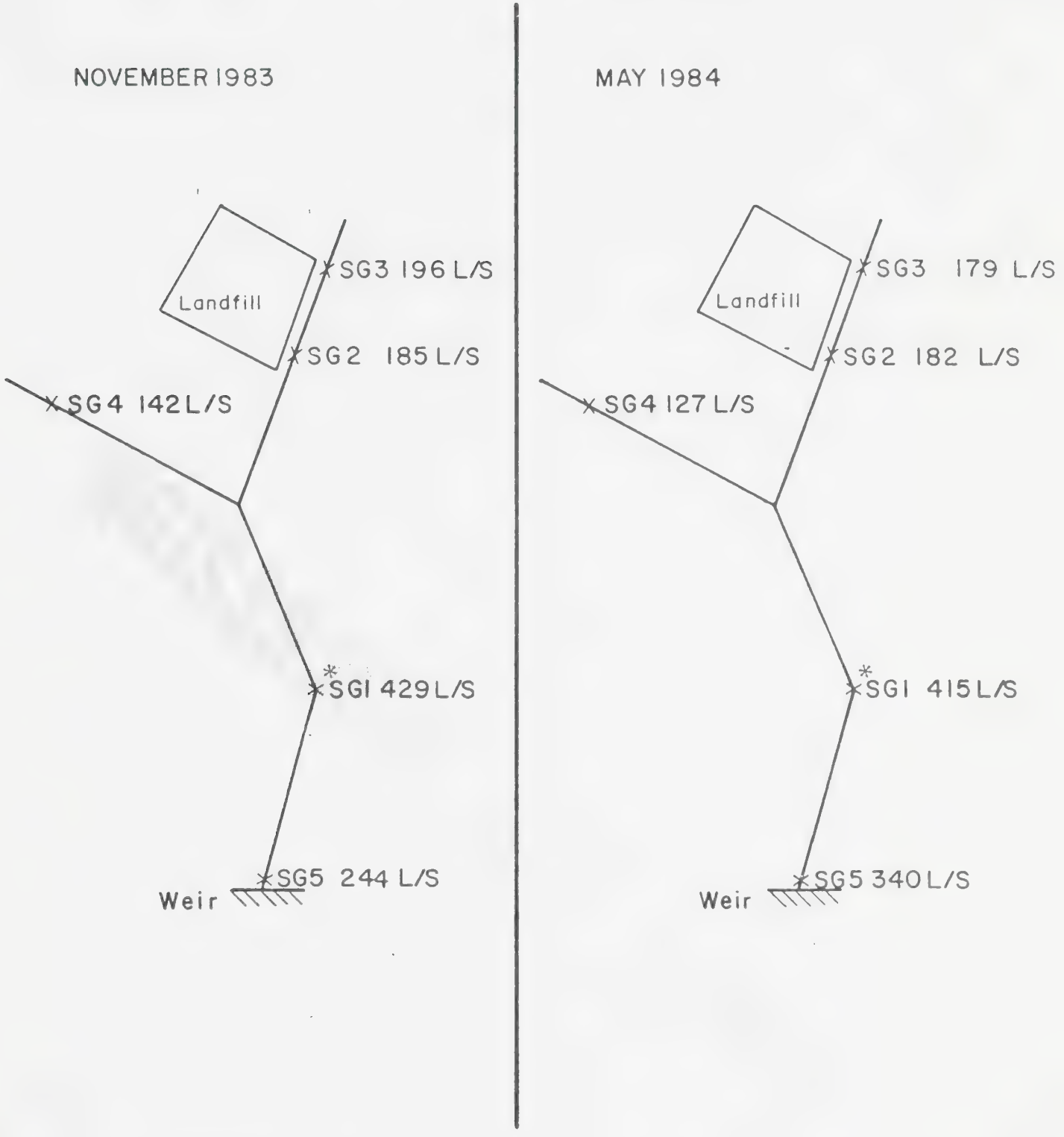
1. Concentration expressed in ug/g (microgram/gram)

2. Oct.31,1979 Analysis by Peninsula Chemical Analysis

3. Nov.25,1980 Analysis by Beak

4. June 3, 1982 and Nov.30,1983, Analysis supplied by Region

Summary of Stream Flow Gaugings



*Gauging results from SG1 (concrete flume structure) were inaccurate.

STREAMFLOW GAUGING RECORD

NOV. 1983

Gauging No. SG 1

Date: 30 Nov, 1983 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 429 ~~m³/sec~~ or L/sec.

Location: Concrete channel section at pipeline crossing
Red Hill Creek

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Snow Showers

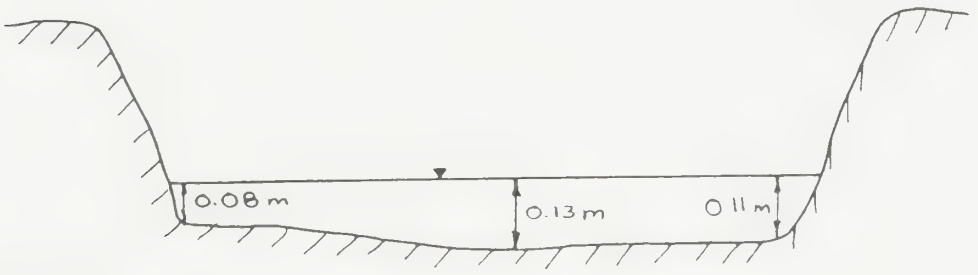
Stream Width 3.75 m. Max. Depth: 0.13 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Red Hill Creek

Description of Bottom: Concrete

Comments: Propeller was partially above water surface during gauging.
Accuracy of gauging is questionable

Sketch: Location - see Site Plan



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STREAMFLOW GAUGING RECORD

Gauging No. SG 2 November 1983

Date: 30 Nov.1983 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 185 ~~xxxxxxx~~ m^3/sec or L/sec.

Location: Red Hill Creek, Eastern Limit of Landfill

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Snow Showers

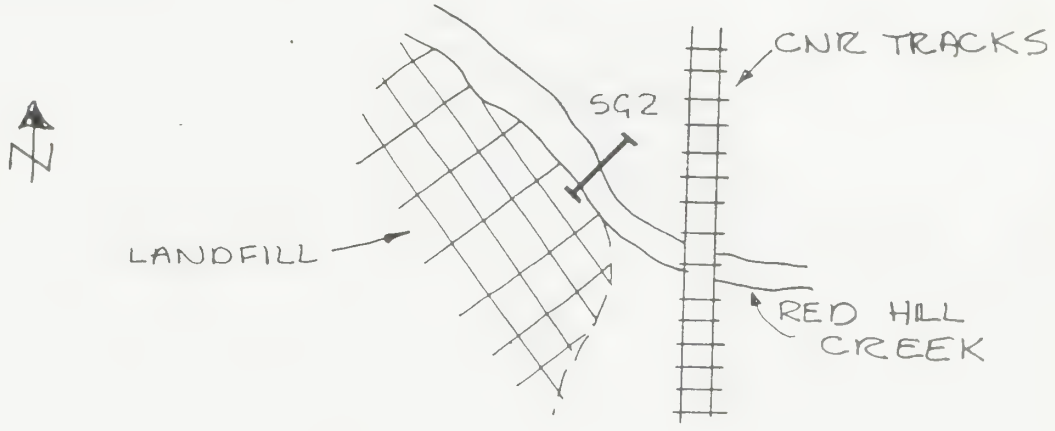
Stream Width: 2.4 m. Max. Depth: 0.17 m. Water Temp.: _____ °C

Clarity: Clear Water Source: _____

Description of Bottom: Mostly hard, stony with occasional softer spots.

Comments: _____

Sketch: Location See Figure 1.



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STREAMFLOW GAUGING RECORD

Gauging No. SG 3

November 1983

Date: 30 Nov.1983 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 196 ~~xxx/sec~~ or L/sec.

Location: Red Hill Creek North End of Landfill just downstream from bedrock exposure

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Snow Showers

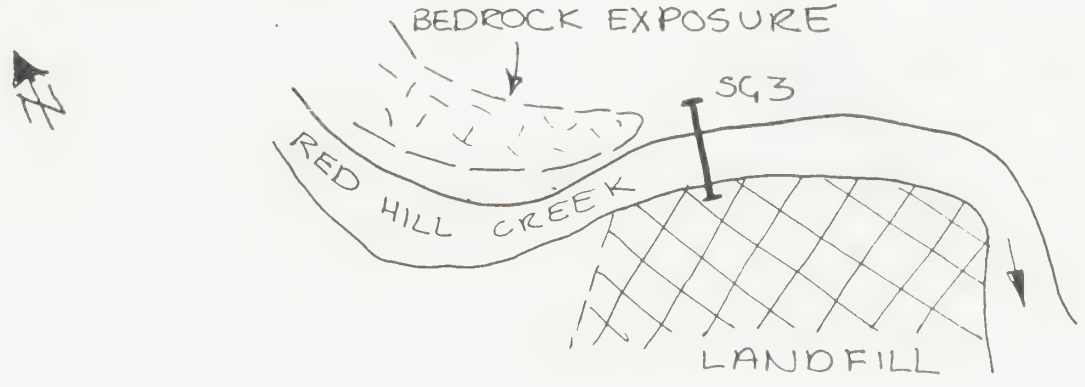
Stream Width: 3.1 m. Max. Depth: 0.2 m. Water Temp.: _____ °C

Clarity: clear Water Source: _____

Description of Bottom: Mostly hard, some bedrock exposed

Comments: _____

Sketch: Location see Figure 1



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STREAMFLOW GAUGING RECORD

Gauging No. SG-4 November 1983

Date: 30 Nov. 1984 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 142 ~~xxxxxxxx~~ m^3/sec or L/sec.

Location: Tributary to Red Hill Creek, Concrete Channel section downstream from Stone Church Road

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Snow Showers

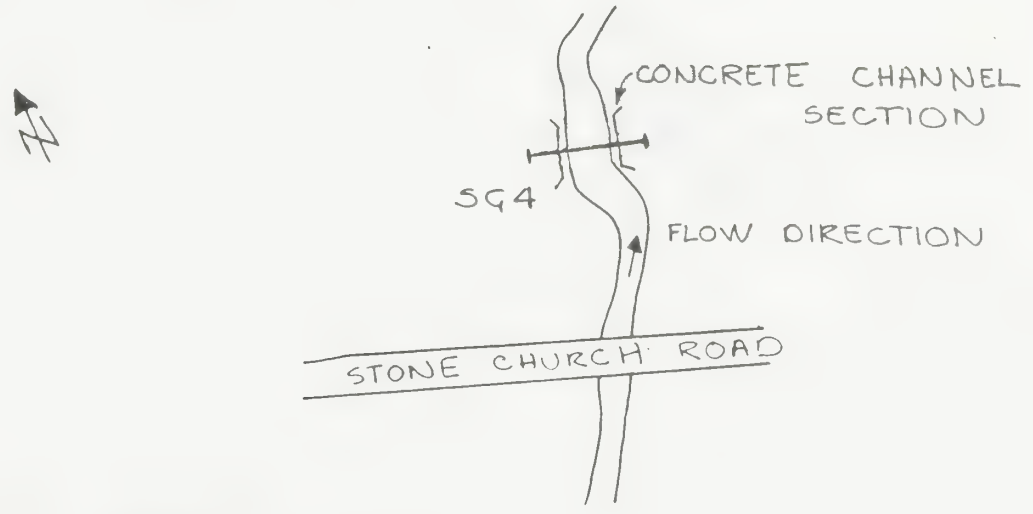
Stream Width: 1.6 m. Max. Depth: 0.25 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Tributary to Red Hill Creek

Description of Bottom: Concrete Channel

Comments: Right bank quite weedy

Sketch: Location - See Figure 1



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STREAM FLOW ESTIMATE — November 1983

SG5 at Albion Falls

DATE: 30 November 1984 PROJECT: 83-115 NAMES: J. McLean
A.G. Hims

FLOW RATE ESTIMATE: 244 L/sec

LOCATION : Red Hill Creek Weir Outlet at Albion Falls,Mud Street

METHODOLOGY: By measuring the dimensions and configuration of the weir using a tape measure and estimating the head, the flow over the weir was estimated.

RESULTS:

L=8' b=24' H=5.7" =0.475'

$L/B = \frac{8}{24} = 0.33$ Thus $K_L = 0.008$

P=36"

$H/P = \frac{5.7}{36} = 0.16$ Thus $C_e = 3.2$

$L_e = 8 + 0.008$

$= 8.008'$

$H_e = 0.475 + 0.008$

$= 0.483$

Flow $Q = C_e L_e H_e^{3/2}$

$= 3.2 \times 8.008 \times 0.483^{3/2}$

$= 8.602$ cfs

$=$ 244 L/sec

STREAMFLOW GAUGING RECORD

Gauging No: SG 1 May 1984

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean

Flow Rate: 415 ~~xxx³/xxsec~~. or L/sec.

Location: Concrete Channel Section at Pipeline Crossing
Red Hill Creek

Meter: PYGMY Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, Breezy

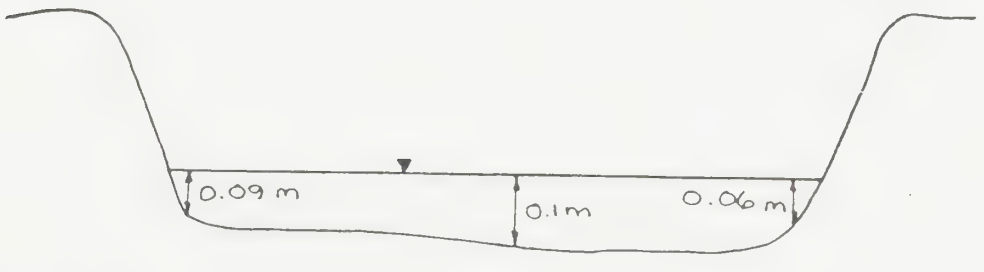
Stream Width: 3.74 m. Max. Depth: 0.1 m. Water Temp.: _____ °C

Clarity: Clear becoming very silty during gauging Water Source: _____

Description of Bottom: Concrete

Comments: Electro-mechanical counter operating too fast to ensure accuracy. Accuracy of gauging is questionable

Sketch:



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STREAMFLOW GAUGING RECORD

Gauging No. SG-2

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean

Flow Rate: 182 ~~m³/sec~~ or L/sec.

Location: Red Hill Creek, Eastern Limit of Landfill

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, breezy

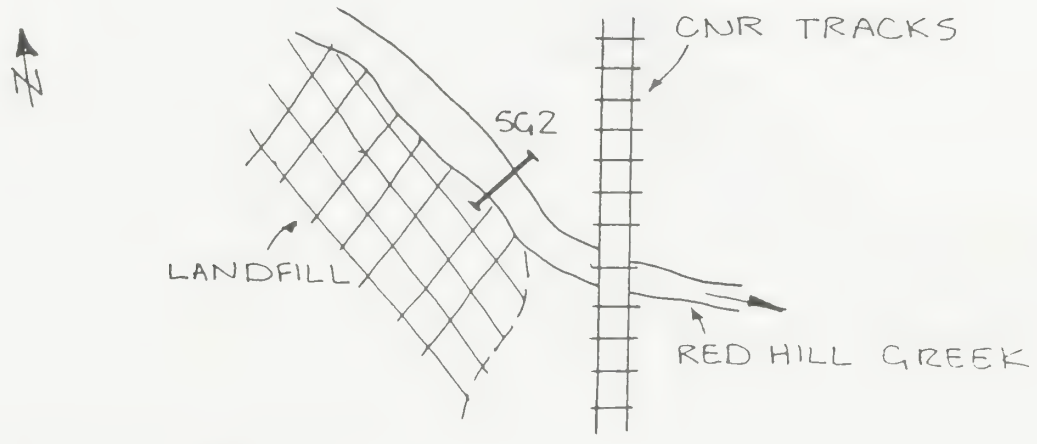
Stream Width: 2.45 m. Max. Depth: 0.19 m. Water Temp.: _____ °C

Clarity: Silty Water Source: Red Hill Creek

Description of Bottom: Mostly hard, stony with occasional softer spots.

Comments: _____

Sketch: Location see Figure 1



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STREAMFLOW GAUGING RECORD

Gauging No. SG 3 May 1984

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 179 ~~m³/sec~~ or L/sec.

Location: Red Hill Creek North End of Landfill just downstream from Bedrock exposure.

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, Breezy.

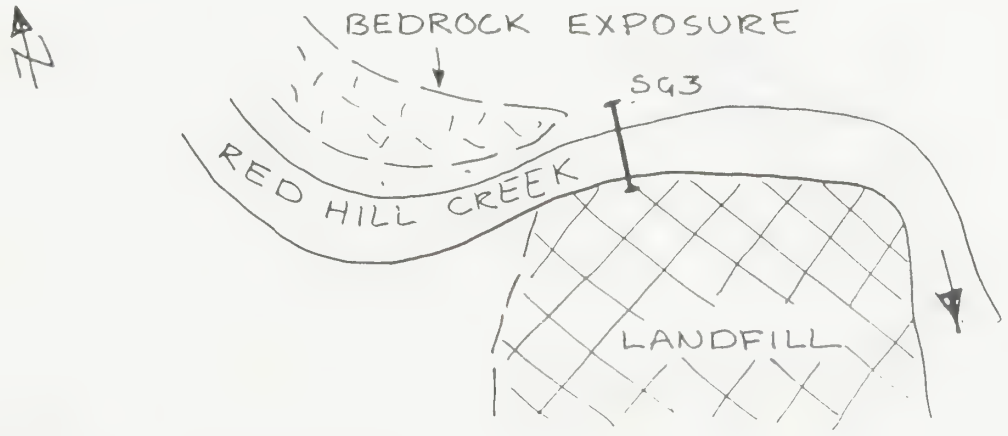
Stream Width: 3.09 m. Max. Depth: 0.28 m. Water Temp.: _____ °C

Clarity: Clear Water Source: _____

Description of Bottom: Mostly hard, some bedrock exposed.

Comments: _____

Sketch: Location see Figure 1



Gartner Lee Associates Limited

STREAMFLOW GAUGING RECORD

Gauging No. SG-4

Date: 127 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 127 ~~m³/sec~~ or L/sec.

Location: Tributary of Red Hill Creek, Concrete Channel section downstream from Stone Church Road

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, breezy

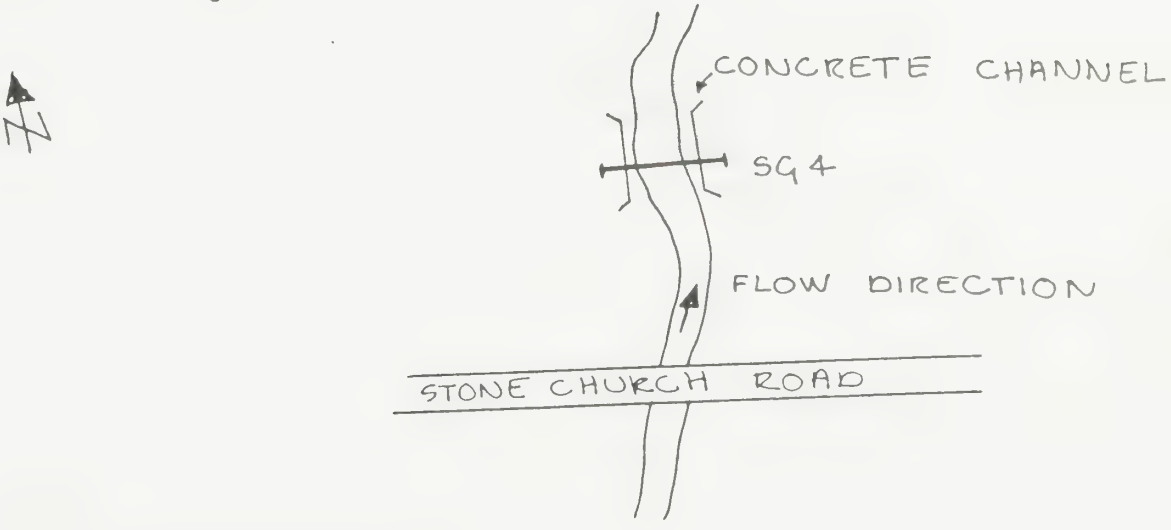
Stream Width: 1.82 m. Max. Depth: 0.28 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Tributary to Red Hill Creek

Description of Bottom: Concrete

Comments: Right Bank quite weedy.

Sketch: Location see Figure 1.



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STREAM FLOW ESTIMATE — May 1984

SG5 at Albion Falls

DATE: 10th May, 1984 PROJECT: 83-115 NAMES: J. McLean
A.G. Hims

FLOW RATE ESTIMATE = 340 L/sec

LOCATION: Red hill Creek Weir Outlet at Albion Falls, Mud Street

METHODOLOGY: By measuring the dimensions and configuration of the weir, using a tape measure and transit, the flow at the weir was estimated.

RESULTS: Datum assumed on weir = 100'

ELEVATION SOUTH END OF WEIR = 91.18' NORTH END =91.19'

AVERAGE = 91.185'

ELEVATION OF WATER WERB = 91.77'

WELB = 91.78'

AVERAGE = 91.775

$\therefore$ HEAD ON WEIR, H. = 0.59'

LENGTH OF WEIR = 8' b=24' L/b = 0.33

P = 3'

H = 0.6' H/P = $\frac{0.6}{3}$ = 0.2

K_L = 0.008 K_H = 0.003 H_e = 0.603

C_e = 3.2

Flow Q = Ce Le $He^{3/2}$ = $3.2 \times 8.008 \times 0.603^{3/2}$

= 12.0 cfs

= 340 L/sec

APPENDIX 2

GROUNDWATER CHEMISTRY

Borehole Logs #1, 4, 6, 9, 11

Table 4 Ground Water Monitor Details

Table 5 Ground Water Chemistry Analysis Results
Boreholes 1, 4, 6, 9, 11 and 12 Nov. 1981 to May 1984

LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

Standard Penetration Resistance 'N' - The number of blows required to advance a standard split spoon sampler 12 inches into the subsoil, driven by means of a 140 pound hammer falling freely a distance of 30 inches.

Dynamic Penetration Resistance - The number of blows required to advance a 2 inch, 60 degree cone, fitted to the end of drill rods, 12 inches into the subsoil, the driving energy being 350 foot pounds per blow.

DESCRIPTION OF SOIL

The consistency of cohesive soils and the relative density or denseness of cohesionless soils are described as follows:

Consistency	'N' Blows/Foot	Denseness	'N' Blows/Foot
Very Soft	0-2	Very Loose	0-4
Soft	2-4	Loose	4-10
Firm	4-8	Compact	10-30
Stiff	8-15	Dense	30-50
Very Stiff	15-30	Very Dense	> -50
Hard	> 30		

W.T.P.L.	-	Wetter than Plastic Limit
D.T.P.L.	-	Drier than Plastic Limit
A.P.L.	-	About Plastic Limit

DESCRIPTION OF ROCK

$$\% \text{ Recovery} = \frac{\text{Total Length of Core Recovered/Run}}{\text{Total Length of Drilling Run}} \times 100$$

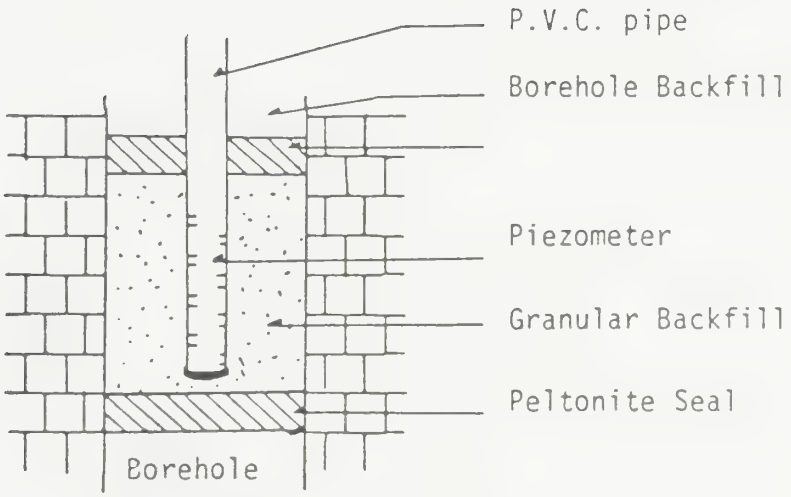
TYPE OF SAMPLE

SS	-	Split Spoon
AS	-	Auger Sample
NX	-	2.16" ϕ Rock Core
▲	-	Water Table Monitor (Standpipe Tip)
●	-	Piezometer Tip

GROUND WATER MONITOR DETAILS

INSTALLATION DETAILS

A. PIEZOMETER: The piezometer consists of an 18 inch long slotted pipe 1¼ inches in diameter. Piezometers are used to measure the hydrostatic pressure, to obtain ground water samples and to measure in situ permeability.



TYPICAL INSTALLATION

B. STANDPIPE: Standpipes consist of P.V.C. or C.P.V.C. pipe with the bottom 10 feet of each standpipe slotted every 1.0 foot. Standpipes are used to measure the ground water table and to obtain ground water samples.

BOREHOLE NO. 1

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 6, 1979

BOREHOLE TYPE BOA 3¼ I.D. HOLLOW STEM AUGERS, 4" TRICONE NX CORE — GEOLOGIST A.B.

ELEVATION 655.4 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		Topsoil						
		TILL: Medium brown clayey silt till, moist						
10.0								
		DOLOSTONE: Medium grey, medium crystalline, thin to thick bedded dolostone, - very cherty - shaly from 31.7' to 35.0'					▲	Goat Island to 25' 4" Tricone to 25'0 Gasport 25-31.7' followed by Decew/ Rochester
			NX			100		
			NX			100	●	
37.5		Borehole terminated at 37.5 in dolostone						

● Piezometer Tip ▲ Standpipe Tip

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BOREHOLE NO. 4

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 20, 1979

BOREHOLE TYPE BOA, 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 674.2 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		GARBAGE						
84.0		DOLOSTONE Medium grey dolostone - cherty					▲	Goat Island

● Piezometer Tip ▲ Standpipe Tip

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BOREHOLE NO. 4 (cont'd)

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 20, 1979

BOREHOLE TYPE BOA, 3¼" HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION _____ — TECHNOLOGIST _____

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
90.0		DOLOSTONE - continued						
105.0		Borehole terminated at 105.0' in dolostone.						

● Piezometer Tip ▲ Standpipe Tip

BOREHOLE NO. 6

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 24, 1979

BOREHOLE TYPE BOA, 3¼" I.D. HOLLOW STEM AUGERS, NX CORE — GEOLOGIST A.B.

ELEVATION 648.8 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.5		TOPSOIL						
		TILL: Medium brown clayey silt till, moist						
5.0		LACUSTRINE CLAYEY SILT: Medium brown clayey silt becoming grey and saturated at ± 15'.						
49.0							▲	
50.0		SAND AND GRAVEL						
		DOLOSTONE: Medium grey, fine crystalline, medium to thick bedded dolostone, cherty minor sphalerite						Goat Island
76.0							●	
		Borehole terminated at 78.0' in dolostone.					●	

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. 9

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 11, 12, 1979

BOREHOLE TYPE BOA 3¼" HOLLOW STEM AUGERS, 3" &4" TRICONES — GEOLOGIST A.B.

ELEVATION 596.2 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		TOPSOIL						
		LACUSTRINE CLAYEY SILT						
5.0		Medium brown clayey silt, moist						
		DOLOSTONE Medium grey dolostone - cherty					▲ ●	Goat Island Dolomite (Ancaster Chert beds)
32.0							●	
		Borehole terminated at 32.0' in dolostone.						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. 11

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE March 4,5, 1980

BOREHOLE TYPE BOA 3¼" I.D. AUGERS, 3" & 4" TRICONES — GEOLOGIST A.B.

ELEVATION 600.6 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		TOPSOIL.						
		LACUSTRINE CLAYEY SILT Medium brown clayey silt, wet; saturated at 3.0' and turning grey at 7.0'					▲	
11.5		DOLOSTONE Medium grey fine crystalline, medium bedded dolostone; cherty to 41.0'; porous from 41.0'-45.7'; becoming shaly dolostone from 45.7'.					●	-36' water is black and has sulphur odour -41.0' Gasport dolostone -45.7' Decew-Rochester shaly dolostone
51.0		Borehole terminated at 51.0' in shaly dolostone.					●	

● Piezometer Tip ▲ Standpipe Tip

GROUND WATER MONITOR DETAILS *

Table 4

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter (in.)	Type	Elev. (a.s.l)	Depth (ft)	Elev. (a.s.l)	Depth (ft)	Elev. (a.s.l)
1	1	1¼	●	656.4 (ft)	37.5	618.9 (ft)	35.0	621.4 (ft.)
	11	½	CPVC ▲	656.4	20.0	636.4	20.0, 9.0, 3.0	636.4, 647.4 653.4
2	1	1¼	●	673.4	73.0	600.4	70.0, 3.0	603.4, 670.4
	11	1¼	▲	673.9	75.0	598.9	65.0, 2.0	608.9, 671.9
3	1	1¼	●	676.4	103.8	572.6	100.3, 1.3	576.1, 675.1
	11	1¼	▲	676.9	80.0	596.9	69.0, 2.0	607.9, 674.9
	111	1¼	▲	678.5	43.5	635.0	22.5	656.0
	1111	1¼	▲	678.5	22.5	656.0	2.5	676.0
4	1	1¼	●	675.0	99.8	575.2	93.8, 1.8	581.2, 673.2
	11	1¼	▲	675.2	85.5	589.7	75.0, 2.0	600.2, 673.2
5	1	1¼	●	657.0	79.0	578.0	75.0	582.0
	11	½	●	657.0	58.5	598.5	58.5, 54.0	598.5, 603.0
	111	½	▲	657.0	54.0	603.0	43.0, 3.0	614.0, 654.0
6	1	1¼	●	650.8	77.0	573.8	74.0	576.8
	11	½	●	650.8	67.0	583.8	67.0, 63.0	583.8, 587.8
	111	½	▲	650.8	50.0	600.8	50.0, 38.0, 3.0	600.8, 612.8, 647.8
7	1	1¼	●	647.1	46.0	601.1	42.5	604.6
	11	½	●	647.1	25.5	621.6	25.5, 21.5	621.6, 625.6
	111	½	▲	647.1	19.5	627.6	19.5, 8.5, 2.5	627.6, 644.6, 638.6
8	1	1¼	●	621.9	69.6	552.3	66.0	555.9
	11	½	CPVC ●	621.7	48.3	573.4	48.3, 44.0	573.4, 577.7
	111	½	CPVC ▲	621.9	24.2	597.7	24.2, 13.0, 1.0	597.7, 608.9, 620.9
9	1	1¼	●	598.2	34.0	564.2	31.0	567.2
	11	½	●	598.1	21.9	576.2	21.9, 19.9	576.2, 578.2
	111	½	▲	598.1	19.9	578.2	8.9, 2.9	589.2, 595.2
10	1	1¼	●	596.4	42.0	555.3	39.0	558.3
	11	½	●	596.5	20.0	577.3	20.0, 18.0	577.3, 579.3
	111	½		596.5	18.0	579.3	7.0, 4.0	590.3, 593.3
11	1	1¼	●	602.6	53.0	549.6	59.0,	543.6
	11	3/4	●	602.6	22.0	580.6	22.0, 17.0	580.6, 585.6
	111	½	▲	602.5	10.0	592.5	3.0	599.5
12	1	1¼	●	N/A	19.0		17.0	
	11	3/4	▲	N/A	13.0		2.0	
G.M.1	1	½	▲	615.8	39.0	576.8	3.5	612.3
G.M.2	1	½	▲	622.2	39.0	583.2	2.5	619.7
G.M.3	1	½	▲	636.6	24.5	612.1	2.5	634.1
G.M.4	1	½	▲	636.6	24.5	612.1	2.5	634.1

● - Piezometer ▲ - Standpipe

Gartner Lee Associates Limited

* All measurements taken from the top of each monitor

GROUND WATER MONITOR DETAILS

Table 4

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter(in.)	Type	Elev.(a.s.l)	Depth(ft)	Elev.(a.s.l)	Depth(ft)	Elev.(a.s.l)
G.M.5	1	½	▲	648.1(ft.)	22.0	626.1(ft)	5.0	643.1(ft.)
G.M.6	1	½	▲	650.5	22.0	628.5	5.0	645.5
G.M.7	1	3/4	▲	650.4	18.0	632.4	3.0	647.4
G.M.8	1	3/4	▲	N/A	18.0	N/A	1.5	N/A
G.M.9	1	3/4	▲	N/A	19.5	N/A	2.0	N/A

● - Piezometer ▲ - Standpipe

TABLE: 5

UPPER OTTAWA STREET

TEST SET GROUP G-B GROUND WATER MONITOR BH1-I SHEET: 1

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	2800	9000	6500	1100	3000	11000
pH	6.9	7.7	6.9	6.75	7.2	7.3
Hardness	1700	238	1275	1320	1140	2010
Alkalinity	380	334	255	244	280	245
Chlorides	140	2500	1983	5400	900	4050
Tot. Kjeldahl	700	710	0.86	1.34	0.08	0.76
Calcium	350	117	375	960	130	700
Free Ammonia	600	7.85	0.30	<.10	0.08	0.04
Nitrate	*	*	5.0	0.19	ND	0.4
Nitrite ug/L	*	*	4.0	2.6	74	6.0
Phenol ug/l	0	0.20	3.07	156	0.08	0
BOD	86	156	5.7	NO	11	20
COD	220	294	118	341	29	397
Sulphate	9773	2750	8750	625	685	950
Phosphate	-	-	-	-	-	-
Phosphorous	0.24	0.10	0.15	0.39	0.01	0.05
PCB ug/l						<0.04
Chromium	ND	ND	0.21	0.04	0.04	ND
Copper	0.2	1.2	0.18	0.06	ND	0.05
Iron	1.4	0.5	4.9	2.20	0.40	<.10
Nickel	<.1	ND	<110	0.08	ND	<.10
Zinc	<1	0.03	0.10	2.78	0.02	ND
Tot. Coliform	70	50	0	270		
Fecal Coliform	10	0	0	0		
Sodium	420	2050	1035	3230	550	2320

TABLE: 5
SHEET: 2

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 4-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	14000	13200				
pH	7.7	7.88				
Hardness	700	309				
Alkalinity	6580	308				
Chlorides	60	400				
Tot. Kjeldahl	1600	697				
Calcium	35	30				
Sodium	3300	1950				
Free Ammonia	1500	499.8				
Nitrate	*	*				
Nitrite	*	*	Not Available	Not Available	Not Available	Not Available
Phenol ug/l	1579	26				
BOD	986	218				
COD	4706	3162				
Sulphate	600	975				
Phosphate	-	-				
Phosphorous	6.0+	4.3				
PCB						
Chromium	ND	ND				
Copper	3.0	7.2				
Iron	5.5	6.4				
Nickel	0.3	0.3				
Zinc	0.4	0.07				
Tot. Coliform	0	900				
Fecal Coliform	0	80				

* Strong colour, prevented analysis
+ Result unreliable, probably high

TABLE: 5

SHEET: 3

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 6-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	-	11500				
pH		7.5				
Hardness		391				
Alkalinity		94				
Chlorides		280				
Tot. Kjeldahl		19				
Calcium		1125				
Sodium		1500				
Free Ammonia		5.0				
Nitrate		*				
Nitrite		*				
Phenol ug/l		0				
BOD		5.75				
COD	Dry	279	Dry	Dry	Dry	Dry
Sulphate		1800				
Phosphate						
Phosphorous		0.14				
PCB						
Chromium		ND				
Copper		1.5				
Iron		1.5				
Nickel		ND				
Zinc		.01				
Tot. Coliform		0				
Fecal Coliform		0				

* Strong colour, prevented analysis

TABLE: 5
SHEET: 4

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 9-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	6000	8100	8000	5800	6500	7500
pH	6.5	7.38	6.5	6.8	6.8	7.1
Hardness	2500	234	2872	3060	2000	2130
Alkalinity	1490	183	1500	1570	500	1310
Chlorides	1350	4250	1523	1690	1715	4100
Calcium	625	107	840	2910	700	600
Sodium	1150	1000	810	1230	1000	1130
Free Ammonia	1100	186	133	90	120	150
Nitrate	0.14	*	17.0	0.05	1.1	0.6
Nitrite ug/l	0.0	*	*	6.0	*	2.0
Phenol ug/l	21	22	12.28	56	0.20	0
BOD	31	36	32	54	28	35
COD	485	515	471	441	529	603
Sulphate	8523	1950	17200	200	3000	1370
Phosphate						
Phosphorous	ND	0.13	0.12	0.26	0.14	0.15
PCB ug/l						<0.04
Chromium	ND	ND	0.15	ND	0.05	ND
Copper	<.1	1.0	<.10	0.05	ND	0.02
Iron	0.3	0.5	0.38	0.10	0.30	0.28
Nickel	0.1	ND	<.10	0.07	0.07	<.10
Zinc	ND	<.01	0.05	0.01	0.03	ND
Tot. Coliform	210	200	10	0		
Fecal Coliform	0	0	0	0		
tot. Kjeldahl	1100	221.34	133	123	210	54.4

* Strong colour, prevented analysis

TABLE: 5
SHEET: 5

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 11-I

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	12000	11800	20500	13500	15000	26000
pH	6.5	7.8	6.8	6.9	6.9	7.5
Hardness	5360	393	7358	8600	6150	10000
Alkalinity	260	304	300	324	170	279
Chlorides	5570	3650	8305	7600	7750	12300
tot.Kjeldahl	4.60	21	5.7	6	5.2	7.2
Calcium	900	875	2170	4400	1900	2670
Sodium	2000	1500	2380	3800	2700	4000
Free Ammonia	1.50	28.6	5.6	6	2.6	60
Nitrate	*	*	<0.1	0.55	ND	1.1
Nitrite ug/l	*	*	6.0	2.6	*	*
Phenol ug/l	7	18	ND	102	ND	0
BOD	123	125	147	126	124	140
COD	625	809	882	515	794	1118
Sulphate	1652	1275	46400	540	1800	1000
Phosphate						
Phosphorous	ND	0.21	0.04	0.13	0.02	0.06
PCB ug/l						<0.04
Chromium	ND	ND	0.40	0.15	0.05	ND
Copper	<.1	1.3	0.13	0.04	ND	0.04
Iron	0.1	1.1	0.53	0.21	0.46	0.25
Nickel	0.2	ND	0.10	0.12	0.12	0.12
Zinc	ND	0.05	0.11	0.04	0.04	0.05
tot. Coliform	10	7600	0	11		
Fecal Coliform	0	30	0	0		

* strong colour, prevented analysis

TABLE: 5
SHEET: 6

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR:BH 12-1

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	1200	1410	1150	1390	900	1700
pH	6.9	8.15	6.8	7.3	7.0	7.6
Hardness	6900	594	545	860	920	730
Alkalinity	260	32.6	275	280	370	248
Chlorides	250	100	161	332	605	500
tot. Kjeldahl	30	1.9	<.1	<1.0	0.03 -	ND
Calcium	200	312	144	620	145	200
Sodium	135	430	63	240	275	120
Free Ammonia	0.30	0.27	<.1	<.1	0.03	0.07
Nitrate	0.08	*	2.0	0.30	0.10	ND
Nitrite ug/l	0.001	*	2.0	4.0	2.0	6.0
Phenol ug/l	0	0	60.1	ND	0.04	0
BOD	3	5.50	2.1	1	12	50
COD	73	56	17.6	382	4	20
Sulphate	400	2500	1700	260	250	205
Phosphate						
Phosphorous	0.14	0.31	0.03	<.01	0.01	0.05
PCB ug/l						<0.04
Chromium	ND	ND	<.10	0.04	ND	ND
Copper	0.2	1.2	<.10	ND	ND	0.03
Iron	2.8	53	0.52	0.85	0.34	0.78
Nickel	<.1	ND	<.10	0.02	ND	<.10
Zinc	0.8	1.1	0.43	0.09	0.41	0.35
tot. Coliform	200	300	120	4		
Fecal Coliform	10	0	0	0		

* strong colour, prevented analysis

APPENDIX 3 - COMBUSTIBLE GAS

Gas Monitor Boreholes GM1 to GM6

Table 6 % Combustible Gas Results - April 1982 to June 1984.

BOREHOLE NO. G.M. 1

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 10, 11, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 614.3 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		LACUSTRINE CLAYEY SILT Medium brown lacustrine clayey silt, moist -turning grey 18.0'						
26.0		DOLOSTONE Medium grey dolostone -cherty					▲	½" Gas monitor installation
38.0		Borehole terminated at 38.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 2

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 10, 11, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 621.7 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		LACUSTRINE CLAYEY SILT Medium brown lacustrine clayey silt, moist						
18.0		SAND AND GRAVEL Medium brown sand and gravel						
25.0		DOLOSTONE Medium grey dolostone -cherty						
39.0		Borehole terminated at 39.0' in dolostone					▲	½" Gas monitor installation

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 3

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 11, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 636.1 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		TILL Medium brown clayey silt till, moist						
8.0								
		SAND AND GRAVEL Medium brown sand and gravel saturated						
13.0								
		DOLOSTONE Medium to dark grey dolostone -shaly						
25.0							▲	½" Gas monitor installation
		Borehole terminated at 25.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 4

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 13, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 632.8 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		TILL Medium brown clayey silt till, moist						
10.0		DOLOSTONE Medium grey dolostone					▲	½" Gas monitor installation
20.0		Borehole terminated at 20.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 5

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 13, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 645.1 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		FILL Medium brown clay silt, boulders, concrete, moist						
6.0		DOLOSTONE Medium grey dolostone -cherty						
19.0		Borehole terminated at 19.0' in dolostone					▲	½" Gas Monitor installation

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 6

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 14, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 647.5 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		FILL Medium brown clayey silt, boulders, concrete, moist						
4.0		DOLOSTONE Medium grey dolomite -cherty						
19.0		Borehole terminated at 19.0' in dolostone					▲	½" Gas Monitor installation

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 7

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE March 4, 1980

BOREHOLE TYPE BOA 3¼" I.D. AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 648.4 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		FILL Mixture of sand, clay, silt, stones, moist						
4.0		DOLOSTONE Medium grey cherty dolostone					▲	3/4" Gas Monitor installation
17.5		Borehole terminated at 17.5' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

PROJECT 83-115 % COMBUSTIBLE GAS TABLE 6 SHEET

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

Date / MONITOR	Apr 22 1982	Oct 27 1982	Dec 12 1982	Apr 20 1983	June 15 1983	Aug 25 1983	Oct 26 1983	Jan 26 1984	Feb 24 1984	Mar 27 1984	Apr 27 1984
GM 1	0	0	0	0	0	0	0	0	0	0	0
GM 2	-	-	0	0	0	0	0	0	0	0	0
GM 3	-	-	0	0	0	0	0	0	0.5	0	0
GM 4	0	0	0	0	0	0	0	0	0	0	0
GM 5	0	0	0	0	0	0	0	0	0	0	0
GM 6	0	0	0	0	0	0	0	0	0	0	0
GM 7	0	0	0	0	0	0	0	0	0	0	0
GM 8	0	0	0	0	0	0	D	E S	T R	O Y	E D
GM 9	0	0	0	0	0	0	0	0	0	0	0
Quonset Hut	-	-	4	5+	5+	-	0	0	0	0	0

NOTE: concentrations in p.p.m. unless otherwise noted.

Gartner Lee Associates Limited

PROJECT 83-115 % COMBUSTIBLE GA TABLE 6 SHEET 2

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

Date / MONITOR	June 27 1984										
GM 1	0										
GM 2	0										
GM 3	0										
GM 4	0										
GM 5	0										
GM 6	0										
GM 7	0										
GM 8	Destroyed										
GM 9	0										
Quonset Hut	0										

NOTE: concentrations in p.p.m. unless otherwise noted.

MONITORING PROGRAM REPORT
UPPER OTTAWA STREET LANDFILL SITE
1982 - 1984 FOR
THE REGIONAL MUNICIPALITY OF
HAMILTON-WENTWORTH

FINAL REPORT

PROJECT NO: 83-115
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JANUARY, 1985

Gartner Lee
Associates Limited

Gartner Lee Associates Limited

Consulting Engineering
Geolologists
Biologists and
Hydrogeologists

Toronto-Buttonville Airport ■ Markham,Ontario ■ L3P 3J9 ■ 416-477-8400
Telex-06-986278

January 25, 1985

Regional Municipality of Hamilton-Wentworth,
Department of Engineering,
71 Main Street West,
Hamilton, Ontario.
L8N 3T4.

Attention: Mr. J.R.G. Leach, P.Eng.
Commissioner of Engineering

Dear Sirs:

Re: Monitoring Program, 1982-1984
Upper Ottawa Street Landfill Site
For 83-115

We respectfully submit our final report to document the results of the monitoring program which has been undertaken jointly by the Region and Gartner Lee Associates Limited at the Upper Ottawa Street Landfill Site between 1982 to 1984.

The report presents and evaluates the results of surface water, ground water, bottom sediment, flood plain and gas monitoring at this site. Recommendations for continued monitoring are also presented.

We trust that the report meets with your satifaction and needs in this matter. Please contact our office if we can be of further assistance on this project.

Yours very truly
GARTNER LEE ASSOCIATES LIMITED

P.K. Lee, M.A.Sc., P.Eng.
Consulting Engineering Geologist

PKL:dg

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1.0 INTRODUCTION:

1.1 BACKGROUND:

This report documents the results of the monitoring program which has been carried out jointly by the Region and Gartner Lee Associates Limited (GLAL) at the Upper Ottawa Street Landfill Site, Hamilton, between 1982 and 1984. The hydrogeological setting of the landfill site is described in two previous reports by GLAL (reports 78-119 and 79-78). A monitoring program was initiated by the Region in 1980 and a report was prepared by GLAL to document the findings of that study (report 80-190, dated March 31, 1983).

Additional hydrogeological studies were commissioned by the Upper Ottawa Street Landfill Site Committee to be carried out in parallel with, but independent from, those programs undertaken by the Region. These additional studies have been very detailed in their scope and have mainly focused on the identification of specific chemical parameters which are present in the ground water and which may be attributable solely to a source within the landfill. The reader is referred to those reports issued by the Committee for further details of their studies.

The work program reported herein was undertaken by the Region and GLAL as a result of the recommendations presented in our previous monitoring report, 80-190. Unlike the detailed studies commissioned by the Committee, the intent of this program is to provide a more

encompassing overview assessment of the effect of the landfill site, in terms of not only ground water aspects but also for surface water quality, and combustible gas hazard. The study area involved lands adjacent to the landfill and extended as far as the Albion Falls area.

1.2 STUDY PROGRAM:

The study program consisted of the following items:

A. By the Region:

(i) The collection and chemical analysis of surface water samples from Redhill Creek at six periods; November 1981, June and December 1982, June and November 1983 and May 1984. Samples were taken at three stations SW1, SW4, and SW7. Samples were collected from station SW2 in November, 1981, June and December 1982 only. Also included was the collection of a leachate sample from the manhole designated MH1. The locations of the sampling stations are shown on Figure 1 in Appendix 4.

(ii) The collection of stream bottom sediment samples at two stations, designated SW1 and SW4 in June 1982 and November 1983 which were used for PCB analysis. Sediment samples were not collected from station SW2.

(iii) The collection of ground water samples at the same times stated in (i) above, from the following six monitor locations:

Borehole 1 - Monitor I (Bedrock)
Borehole 4 - Monitor I (Bedrock)
Borehole 6 - Monitor I (Bedrock)
Borehole 9 - Monitor I (Bedrock)
Borehole 11 - Monitor I (Bedrock)
Borehole 12 - Monitor I (Bedrock)

B. By Gartner Lee

(i) The measurement of streamflows at four stations along Redhill Creek and at one station in the tributary to Redhill Creek, designated as SG1 to SG5 inclusive in Figure 1. The measurements were to be carried out in November 1983 and May 1984 to coincide with the surface water sampling program.

(ii) The inspection of the Redhill Creek floodplain lands and the Escarpment Face at Albion Falls in November 1983 and May 1984. The intent of the inspections was to identify the presence

of leachate springs, if present, in the floodplain lands. Gartner Lee staff were accompanied during both inspections by a representative from the Upper Ottawa Street Landfill Site Committee.

(iii) The anlysis of all monitoring data obtained between the period of 1982 to May 1984.

(iv) The preparation of a report to document the results of the entire monitoring program undertaken by both the Region and Gartner Lee.

1.3 LIMITATIONS OF ACTUAL MONITORING PROGRAM:

The monitoring program which has been undertaken has not provided the complete set of data required to quantitatively define the relationship between the landfill site and the surface water/ground water flow systems. It appears that the data base obtained during this specific monitoring period with respect to the surface water, sediment chemistry and streamflow measurements is insufficient and that the seasonal monitoring as previously established, is not entirely suitable. The streamflow measurements and visual observations which have been made along Redhill Creek, indicate that the creek is prone to erratic or periodic flash discharges from location(s) upstream from the landfill site. In particular, the sediment load in the creek was observed to increase dramatically, and then decrease again, within a short period of time (a few hours).

In light of the results of this present program, we have made recommendations to change the 1985 monitoring program in order to take into account the nature of the surface water flow system. We expect that future monitoring will then allow a more complete understanding of the overall effect of the landfill site on the surrounding area.

2.0 SUMMARY OF RESULTS:

A summary and discussion of the highlights of the results of the monitoring program are presented in this section. Further discussion and details of the work and results are presented in Section 5.0 at the end of the report.

2.1 SURFACE WATER CONSIDERATIONS:

The surface water chemistry data and streamflow gauging results which have been obtained during the monitoring program do not provide a definitive detailed effect, that can be attributed to the landfill site, on the water quality in Redhill Creek. Mass balance calculations to assess the magnitude of the chemical loading from the landfill cannot be determined with a high degree of accuracy during the high flow periods due to the erratic nature of streamflow and sediment load in the creek during these periods.

In terms of the chemical concentration of specific parameters within Redhill Creek water at the time of sampling, the following general comments are provided. A limited amount of data are available until December 1982 at station SW2, located immediately downstream from the landfill. However, our review shows that for the parameters measured, the concentrations were consistently higher at SW2 compared to the monitor station upstream from the landfill, at station SW4. Further downstream at station SW1, for which data are available until May 1984, the concentrations of iron, ammonia and TKN (except May 1984) are elevated above upstream values. The concentration of other parameters, however, such as conductivity,

chloride, phenol and BOD at the downstream stations is sometimes less than, and sometimes greater than, the upstream location.

Thus, whereas it is apparent that the water quality in Redhill creek is generally poorer below the landfill site, compared to upstream from the landfill, it is not possible at this time to calculate with accuracy, effects related to the landfill. However, visual observations of leachate springs discharging directly into the creek indicate that the landfill site does have some degree of effect on the water quality in the creek in combination with those upgradient.

In order to better define long-term trends in water quality, we have suggested that additional monitoring in Redhill Creek and its tributary be undertaken during 1985. As part of the proposed program, we have suggested that the previously established data base be supplemented with ground water/surface water chemistry and streamflow data during a period of sustained low-flow during the late summer or early fall period. This program should provide the additional data necessary to determine a clearer understanding of the relationship between the landfill site and the ground water/surface water setting.

A monitoring program is suggested in Section 3.1. A comparison of complete data base for any one monitor period may be more reliable than that of season to season.

2.2 REDHILL CREEK SEDIMENT:

The results of the PCB analyses on sediment samples from Redhill Creek continue to indicate that a source of PCBs exists upstream from the landfill site. The data also suggest that some degree of additional source of PCBs may be present within the landfill as indicated by the increased concentration of PCB in the sediment at the downstream station SW1 in November 1983. PCBs have been detected in past studies both in the interior of the landfill (Borehole 2 location) and in the leachate obtained from manhole MH1. Additional monitoring is suggested in Section 3.1.

2.3 GROUND WATER CONSIDERATIONS:

The results of the ground water monitoring program confirm that leachate originating within the landfill site is continuing to migrate in the bedrock ground water flow system away from the fills. The effect of the leachate on the ground water quality is, in part, masked by the natural poor quality and variability of the ground water associated with the underlying Rochester shale beds. The ground water quality at boreholes 9 and 11 certainly appears to be degraded compared to the natural background quality in terms of conductivity and chloride and also TKN at borehole 9. Also, the concentration of the parameters measured appears to be increasing with time.

Additional monitoring of ground water quality is required in order to establish long term trends. A program is suggested in Section 3.2.

2.4 REDHILL CREEK FLOODPLAIN INSPECTION:

The conditions which were observed within the floodplain lands during the November 1983 and May 1984 inspections were essentially similar to those previously documented in earlier reports. The detailed inspection along the northern limit of the landfill revealed several leachate seeps discharging directly into Redhill Creek. The majority of the seeps were located immediately above the concrete protection mat on the face of the landfill. Seeps were also observed at various elevations on the landfill face beyond the western limit of the concrete mat. We suggest that remedial action be taken along these sections to prevent the seepage from discharging directly into Redhill Creek. Since there is no leachate collection system along Redhill Creek, it will not be possible to prevent some leachate from seeping through the concrete protection mat and discharging into the creek. With regard to the leachate springs present at the top of the protection mat, the slope should be regraded and clean granular fill placed over the leachate springs. The granular material should extend down behind the top of the protection mat a short distance so that leachate is directed downwards behind the mat.

2.5 COMBUSTIBLE GAS:

Combustible gas has been detected in potentially explosive concentrations in the Quonset hut on three occasions in 1982-1983. The monitoring location in the Quonset hut was a hole cut through the floor beneath the sink, to allow waste water to drain away. The hole was plugged in September 1983, and gas has not been detected in the hut since that time. Gas has been detected in gas monitor GM3 on one occasion in February 1984. It is suggested that monitoring continue at these two locations on a monthly basis until May, 1985. The results should then be assessed and the need for continued monitoring can be re-evaluated at that time.

3.0 FUTURE MONITORING PROGRAM:

The following monitoring program is recommended for 1985:

3.1 SURFACE WATER AND SEDIMENT:

Samples of surface water should be obtained from both Redhill Creek and its tributary in April - May (high flow conditions) and August - September (low flow conditions). The stations to be sampled are SW1, SW2, SW4, SW7 and the tributary immediately upstream from the junction with Redhill Creek. The parameters to be considered for analysis are conductivity, pH, chlorides, total kjeldahl nitrogen, iron, ammonia phenol, BOD and PCB.

Streamflow measurements and mass balance loading calculations should be undertaken during the August - September monitoring. This monitoring should be carried out during a period of sustained low flow. Flows should be measured at each sample station at the same time that the samples are taken. We have not recommended streamflow measurements during the April - May monitoring due to the apparently erratic and flash flow nature of the basin during high flow conditions.

Sediment samples should be obtained on the same day as surface water smaples are collected and analysed for PCB content. The stations to be sampled are SW1, SW2, SW4 and the tributary immediately upstream from Redhill Creek.

3.2 GROUND WATER:

A ground water monitoring program which is similar to that carried out previously should be continued in 1985. Ground water samples should be obtained from the bedrock monitors at boreholes 1, 6, 9, 11 and 12. Parameters to be analysed should be the same as those listed in Table 6, Appendix 2. Sampling should be carried out on the same day sas the surface water sampling program. It is very important that the ground water monitors be properly developed prior to sampling. We suggest that a minimum of 2 wellbore volumes of water should be removed from each monitor prior to sampling. To facilitate this development, consideration could be given to the use of a compressed nitrogen airlift system and dedicated tubing at each monitor location.

3.3 COMBUSTIBLE GAS:

Monitoring for combustible gas should be continued on a monthly basis until May 1985 at the Quonset Hut and gas monitor GM3. The results should then be evaluated to assess the need for continued monitoring through the remainder of 1985.

4.0 RECOMMENDATIONS:

The following recommendations are submitted:

- A surface water, ground water and gas monitoring program should be carried out in accordance with the details provided in Sections 3.1, 3.2 and 3.3 of this report and as summarized in Table 1.

- Remedial action should be taken along the upper portion of the concrete retaining face of the northern boundary of the landfill to prevent the leachate seeps from entering Redhill Creek.

- the results of the monitoring program and remedial action should be evaluated by a qualified hydrogeologist and documented in a report for the year.

It is anticipated that the additional monitoring should provide a clearer understanding of the relationship between the landfill site and the ground water/surface water setting.

TABLE 1: SUMMARY OF RECOMMENDED MONITORING PROGRAM, 1985

	SCHEDULE	TYPE OF MONITORING
Surface Water Stations SW1, SW2, SW4, SW7 and Tributary to Redhill Creek immediately upstream from junction.	May (High Flow) August-September (Low Flow)	Chemical Analysis: Conductivity, pH, chloride Total Kjeldahl Nitrogen, Iron Free Ammonia, Phenol, BOD and PCB. Sediment Chemical Analysis: PCB at all stations except SW7. Stream Flow Gauging: At all stations during August-September monitoring only.
Ground Water Bedrock monitors at Boreholes 1, 6, 9, 11 and 12	May August-September (same day as surface water sampling)	Chemical Analysis: Conductivity, pH, Hardness, Alkalinity, chloride, Total Kjeldahl Nitrogen, Calcium, Free Ammonia, Nitrate, Nitrite, Phenol, BOD, COD, Sulphate, Phosphorous, PCB, Chromium, Copper, Iron, Nickel, Zinc, Sodium.
Gas Quonset Hut, Monitor GM3	Monthly until Spring 1985	Monitor for combustible gas.

5.0 DETAILED STUDY FINDINGS:

The detailed results from the various component sections of the monitoring program are provided in the technical appendices at the back of the report. The results from each section are presented below:

5.1 SURFACE WATER

5.1.1 CHEMISTRY RESULTS

The results of the chemistry analyses, carried out on surface water samples between November 1981 to May 1984. are presented in Table 2, in Appendix 1. Table 2 presents the results of the chemistry analyses on leachate samples from manhole MH1 over the same time period.

Figures 2 to 6 present graphically the change in concentration with time for specific parameters between 1979 to 1984 (as available), at the four surface water stations and for leachate from manhole MH1. The parameters presented are Conductivity (umhos/cm), Chloride (mg/L), Total Kjeldahl Nitrogen -TKN (mg/L) and Phenol (ug/L).

Figure 2 presents these data for station SW4 which is located on Redhill Creek, upstream from the landfill site. This is regarded as background surface water quality, and as such, it is the base against which the surface water adjacent to, and downstream from the landfill, is compared.

The conductivity at station SW4 has remained relatively stable since late 1982 at between 800 to 1000 umhos/cm and has actually showed an apparent general decrease. The chloride concentration has fluctuated to a greater degree and has increased slightly since 1981, from a value of 85mg/L to 118 mg/L in May 1984. It should be noted however, that both the chloride content and conductivity reached a peak value in May 1981 (395 mg/L and 2110 umhos/cm). The values have consistently declined and have been lower since that time.

The TKN concentration has decreased since the initial monitoring in 1979 and since 1982 the value has remained below 1 mg/L. The exception to this is the most recent sample, that of May 1984, when a value of 2.48 mg/L was reported.

The Phenol concentration has fluctuated more than any other parameter and has varied quite substantially ranging from a value below the detection limit to 15 ug/L in June 1983.

Figure 3 presents the chemistry data for leachate obtained from manhole MH1. Table 3, Appendix 1 presents the results of the analyses. These data are presented here to illustrate the relative strength or concentration of the leachate within the landfill. The conductivity has varied from a high of 15000 uhos/cm in 1982 to a low of 7500 uhos/cm in November 1983. The leachate has exhibited an apparent trend of decreasing conductivity with time.

All of the other three parameters (Cl, TKN and phenol) showed marked decreases in the study period. The chloride concentration was consistently about 3000 mg/L from late 1982 until May 1984 when the value dropped to 1750 mg/L. The concentration of TKN has exhibited large fluctuations from 540 mg/L in June 1982 to 11.2 mg/L in May 1984. The concentration of phenol also appears to be following a decreasing trend, dropping from a value of 281 ug/L in 1982 to 1.38 ug/L in November 1983.

Figure 4 presents the chemistry data from Station SW2 which is located on Redhill Creek adjacent to the railroad bridge at the eastern boundary of the landfill site. The data set is incomplete as the surface water has not been sampled at this location since December 1982. During the time period for which data are available, the conductivity and Phenol concentration was essentially similar to Station SW4 (see Fig. 2). Both the chloride and TKN concentrations at SW2 were consistently elevated above the values at SW4.

Figure 5 presents the chemistry data from station SW1 located on Redhill Creek immediately upstream from the pond which is adjacent to Albion Falls. The conductivity of the creek at this station has remained relatively stable and is similar to that measured at SW4. The chloride concentration has exhibited a greater degree of fluctuation and overall slight increase which is a similar trend to that observed at SW4. Between 1980 and 1982 the actual value was slightly lower at SW1 than SW4. In 1983 the value was slightly higher at SW1 and then lower in May 1984. The concentration of TKN has been greater at SW1 than SW4, although the trend of decreasing value with time is similar.

TKN was not detected at SW1 in May 1984. With regard to the Phenol concentration at SW1, both the trend and the actual values are similar to those observed at SW4. Phenol was not detected in 1984, whereas a value of 19 ug/L was reported in June 1983.

Figure 6 presents the chemistry data obtained from SW7 which is located on Redhill Creek below Albion Falls. This data set represents the periods of June 1982 and May 1984. Both the conductivity and chloride values were similar at SW7 and SW4 in May 1984 (900 umhos/cm conductivity at both stations and chloride values of 112 mg/L at SW7 and 118 mg/L at SW4). The concentration of TKN was higher at SW7 in 1982 (4.4 mg/L whereas it was slightly lower than SW4 in 1984 (0.52 mg/L). Phenol has not been detected at SW7 at the times of sampling.

5.1.2 STREAMFLOW GAUGING RESULTS

A summary of the results of the streamflow gauging is presented together with the individual data sheets in Appendix 1.

The results obtained in May 1984 provide the highest degree of correlation between the flow measurements taken in Redhill Creek and its tributary compared to the estimate of flow over Albion Falls.

In summary, the May 1984 streamflow gauging results indicate the following:

(a) the streamflow in Redhill Creek adjacent to the landfill was in the order of 180 L/sec.

(b) the streamflow in the tributary creek was about 130 L/sec.

(c) the water flow over Albion Falls via the weir was about 340 L/sec.

The discrepancy between the total flow measured in the creek and its tributary compared to the flow estimate over Albion Falls can be explained by a combination between the following factors:

(i) accuracy of streamflow gauging ($\pm$10%)
(ii) accuracy of flow estimate at Albion Falls ($\pm$10%)
(iii) ground water discharge to creek between gauging stations and Albion Falls.

5.2 REDHILL CREEK SEDIMENT:

The results of the PCB analyses which have been carried out on samples of the bottom sediment from stations SW1, SW2 and SW4 are presented in Table 4, Appendix 1. Trace ammounts of PCBs were identified in the sediment at SW4 and SW1 in June 1982 and November 1983. In the 1982 sampling, the concentrations in the sediment were similar both upstream (SW4) and downstream (SW1) from the landfill. In the November 1983 sampling, the concentration downstream from the landfill was approximately twice as high as that reported for upstream at SW4 (0.034 ug/g at SW1, 0.018 ug/g at SW4).

As indicated in our previous monitoring report, GLAL 80-190, the presence of PCBs in the creek sediment upstream from the landfill indicates that a source of PCBs exists somewhere upstream. The increase in PCB concentration in the sediment downstream from the landfill at SW1 may indicate an additional contribution from the landfill. The evidence at this time is not conclusive.

It should also be noted that during the streamflow gauging in May 1984, the sediment load in Redhill Creek increased dramatically during the site visit. In fact, the sediment load became great enough to impart a creamy colouration to the water. The increase in sediment load was apparent

in the creek upstream from the landfill site, indicating an external (upstream) source. The sediment load and colouration also decreased as rapidly as it had increased.

5.3 REDHILL CREEK FLOOD PLAIN INSPECTION:

On November 30, 1983 and May 10, 1984, Mr. Hims carried out a detailed inspection of the Escarpment lands which form the Redhill Creek valley walls and floodplain area east (downstream) of the landfill site. Mr. Hims was accompanied during parts of the inspection by Mr. J. Barbash on November 30, 1983, and by Mrs. A. Beaufrey on May 10, 1984, both of whom were present as representatives of the Upper Ottawa Street Landfill Site Committee.

The areas of interest are identified on Figure 1 by the same designation as was used in our previous monitoring report. Details are as follows:

November 30, 1983 May 10, 1984

Area A
(Albion Falls)

The spring, designated A, is a small seepage area about 3 m below Mountain Road on the south side of the falls.

Flow was not discernible at the rock contact. Small patches of iron-red staining were evident. Water was ponding in the grassed area immediately below the spring. Surface run-off from a road culvert may also contribute to this ponding. Conductivity of water was 2950 umhos/cm. No odour was noted. Conductivity of surface water flowing over falls was 1250 umhos/cm.

Seepage was evident at the rock face 1 L/min. The rock was discoloured iron brown and a slight oily film was evident on the water surface. Clear water with no odour was discharging from the culvert.

Area B

No springs nor seepages were evident along this section of Redhill Creek during both inspections.

Area C

Location C is the concrete channel lining associated with a buried sewer pipe crossing. Streamflow gauging SG1 was carried out at this location.

A dark brown and green staining and seepage (± 1 L/min) was present about half way up the channel lining on the south side. A pool of standing water was present behind the north side of the concrete lining. The water had an oily film on the surface and the conductivity was 3250 umhos/cm. Creek water conductivity was 1350 umhos/cm. An odour of hydrogen sulphide was present at this location.

Similar conditions were observed at location during this inspection except that the oily film was not present on the pool of water.

Areas C to D

No seepages nor springs were noted along this section of the creek. At the concrete outfall structure, water was discharging into Redhill Creek at a rate of about 4 L/min. The conductivity was 1650 umhos/cm. The conductivity of the creek upstream was 1400 umhos/cm.

Several small seepages were noted in the floodplain through this section. The water was clear with no odour. The largest seepage area was at location K just above the floodplain. The seepage formed a small stream which discharged into Redhill Creek. The water was clear with no odour. A small slope failure was evident immediately downstream from the concrete outfall structure. Slight seepage was evident on the failure surface.

Areas E to H

These areas are located along the tributary to Redhill Creek.

No seeps nor springs were noted. The conductivity of the tributary water was between 1125 to 1200 umhos/cm. The conductivity of the Creek upstream from the tributary was 1350 umhos/cm.

The sediment loading in the tributary was substantially greater than in Redhill Creek.

One spring was noted at location G on the east bank of the tributary. Some brown staining was evident on the ground surface and the water had an oily sheen on the surface. No odour was present.

Occasional pondings of standing water were present on the landfill side. The water varied from clear to slightly murky. No odour was present.

Areas I and J

These are surface water ponds adjacent to the valley walls. The water was generally clear, odourless and the conductivity ranged from 700-800 umhos/cm.

Similar conditions were observed during this inspection. The area around Borehole 9 was also wet at this time. The water was clear and odourless. Some channelization was apparent and algal growth was apparent within the channels.

Redhill Creek Adjacent to Landfill

Streamflow gauging SG2 was carried out just upstream from the railroad bridge. The conductivity of the creek water was 1525 umhos/cm. A general inspection was carried out along this section of the creek up to the concrete stilling structure. Several small (<1 L/min) discoloured seepages were observed at various locations and elevations on the concrete retaining face of the landfill. The seepages discharged directly into the creek. Gas was noted venting in portions of the creek bed. Discoloured and odourous seepages were also noted in the faces of

A more detailed inspection was carried out along this section of the creek during this visit. The locations are noted on Figure 1.

Location 1 at toe of landfill site. A small discharge of black-green liquid was present from the culvert (± 6 L/min) into the creek.

Location 2 - No seepages nor staining noted in toe protection.

Location 3 - Small discoloured seepage present at the top of the concrete protection.

the landfill at several locations at the north end where there was no concrete retaining faces. The conductivity of the creek water at the north end was 2100 umhos/cm. The conductivity of the creek water at streamflow gauging station SG3, opposite the landfill, was 2400 umhos/cm.

Location 4 - Occasional seepages present in concrete protection. Gas venting through creek bed.

Location 5 - Discoloured seepage area present at top of concrete protection. Dark coloured liquid seeping into creek (<1 L/min).

Location 6 - Occasional seeps and/or stained areas noted.

Location 7 - Discoloured seepage area was present about 15 m long at top of the protection. Liquid is brown and oily and gas was venting through the fills. Seepage was entering the creek ($\pm$ 1 L/min).

Location 8 - Occasional small seepages or discolourations present.

Location 9 - The concrete protection has bulged at the toe of this location. Seepage out of the fills was occurring above the protection and gas venting was also noted. A scummy brown liquid was seeping into the creek (<1 L/min).

Location 10 - No seepage noted along this section.

Location 11 - Occasional small seepages were noted along this section.

Location 12 - Occasional small seepages were noted at the top of the concrete protection along this section.

Location 13 - The concrete protection ends at this location.

Location 14 - Seepage and soil erosion from the face was observed at this location. The toe of the fills had bulged into the creek bed and was being actively eroded.

Location 15 - At the streamflow gauging station SG3 - No seepages present.

Location 16 - A small seepage was present at the toe of the slope and red brown staining was present. Erosion of the surface soils had occurred at this location with subsequent gully formation down the face of the fills.

Location 17 - No seepages noted in this area.

Location 18 - Occasional seepages were present at the toe of the slope. The liquid had an oily sheen and red brown staining of the ground surface had occurred.

Location 19 - Small discoloured seepages were present at the toe of the slope in this location. Also some surface erosion and gullying had occurred.

5.4 GROUND WATER:

The borehole logs for those groundwater monitors which were sampled are included for reference in Appendix 2. The details of the groundwater monitors are presented in Table 5. All the bedrock monitors are screened in the dolostone or shaly dolostone bedrock formation.

Table 6 in Appendix 2 presents the chemistry analysis results which have been obtained between November 1981 and May 1984 from groundwater samples from the bedrock monitors in boreholes 1, 4, 6, 9, 11 and 12, Figures 7 to 12 graphically present the chemical concentration versus time for these monitors. The parameters illustrated are Conductivity (umhos/cm) Chloride (mg/L), Total Kjeldahl Nitrogen, TKN, (mg/L) and Phenol (ug/L), as per the surface water stations.

Figures 7 and 8 present these data for the bedrock monitors in boreholes 1 and 12, both of which are located upgradient from the landfill site. As stated in our previous monitoring report, 80-190, the ground water quality from these two monitors is poor due to probable influences from the Rochester shale which underlies the Lockport Dolomite. The bedrock ground water from borehole 1, upgradient in the flow, in particular has exhibited substantial natural fluctuations (orders of magnitude) in chemical content since 1981. The conductivity and chloride concentration in this monitor in May 1984 were 11000 umhos/cm and 4050 mg/L respectively. The corresponding values for Borehole 12 were 1700 umhos/cm and 500 mg/L. The phenol and TKN concentrations in both monitors have varied between values in the 10-100+ range in 1981-1982 (ug/L phenol and mg/L TKN) down to below the detectable limit in 1983 and 1984.

Figures 9 and 10 present the data for Borehole 4, and Borehole 6 which is downgradient from the fill. Data are only available until May 1982 and, with the exception of a relatively consistent, high conductivity (10,000+umhos/cm) in both monitors, no other trends are apparent.

Figure 11 presents the data for Borehole 9, located east of and downgradient from the landfill site within the Redhill Creek flood plain. The conductivity has remained relatively stable at between 6000-8000 umhos/cm. The chloride concentration has fluctuated between about 1500-4000+ mg/L occasionally, but generally shows an overall slight increase with time. The concentration of TKN has fluctuated with time, but has generally remained at about 100-200 mg/L. The phenol concentration has remained around 10 ug/L until November 1983 when a value of 0.2 ug/L was reported, and phenol was not detected in May 1984.

Figure 12 presents the data for Borehole 11, which is located to the southeast and downgradient from the landfill site. The conductivity and chloride concentration shows a similar trend overall of increasing value with time. The May 1984 values were 26000 umhos/cm for conductivity and 12300 mg/L for chloride. These values are greatly in excess of the concentrations reported for the leachate from manhole 1. Reference to Table 5 sheet 5 in Appendix 2, shows that the concentration of most parameters tested is relatively high and generally increasing with time.

5.5 COMBUSTIBLE GAS:

Details of the gas monitor boreholes 1 to 9 are presented on the logs in Appendix 3. Table 7 (2 sheets) presents the results of the gas monitoring which has been carried out at the site from April 1982 until June 1984.

With the exception of the Quonset hut and GM3, combustible gas has not been detected in the monitors at the site.

Combustible gas in concentrations of 4% to 5+% was detected in the Quonset hut in December 1982, April and June 1983. The monitoring location in the Quonset hut was a hole cut through the floor beneath a sink to allow waste water to drain away. The hole was plugged in September 1983, and gas has not been detected in the hut since that time. Gas was detected in GM3 at a concentration of 0.5% in February 1984.

Respectfully submitted

GARTNER LEE ASSOCIATES LIMITED

A.G. Hims, P.Eng.
Project Manager

APPENDIX

APPENDIX 1 - SURFACE WATER

Table 2 Surface Water Chemistry results (Nov 1981 to May 1984).

Table 3 Leachate Chemistry Results From Manhole M#1 (Nov.1981 to May 1984).

Table 4 Results of PCB Analysis on Sediment Sample (Oct. 1979 to Nov. 1983).

Summary of Streamflow Gaugings

Streamflow Gauging Records SG1 -SG5 Nov.30,1983

SG1 -SG5 May 10,1984

PROJECT 83-115 TABLE 2 SHEET 1

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW1 TESTED BY Collected and Tested by Region

PARAMETER \ DATE	Nov.26 1981	June 3 1982	Dec.8 1982	June 7 1983	Nov.11 1983	May 10 1984					
Conductivity(umhos/cm)	1050	1780	900	1020	750	850					
pH	7.5	8.04	7.6	7.65	7.4	7.7					
Chloride	95.5	22	94	110	185	108					
tot.Kjeldahl Nitrogen	5.2	3.4	0.32	1.24	0.44	not Detect.					
Iron	0.6	-	0.44	0.17	0.49	0.20					
Ammonia	2.4	2.1	<0.1	0.24	0.44	0.34					
Phenol (ug/L)	3.5	1.5	not Detect	19	0.04	0					
BOD	5.6	4.5	2.7	not Detect	13	5					

NOTE: concentrations in p.p.m. unless otherwise noted.

Gartner Lee Associates Limited

PROJECT 83-115 TABLE 2 SHEET 2

WATER ANALYSIS RESULTS

SAMPLING LOCATION Surface Water Station SW2 TESTED BY Collected and Tested by Region

PARAMETER \ DATE	Nov 26 1981	June 3 1982	Dec 8 1982								
Conductivity(umhos/cm)	1200	1550	1050								
pH	7.7	8.17	8.0								
Chloride	125	205	115								
tot.Kjeldahl Nitrogen	3.0	3.4	0.4								
Iron	<0.1	-	0.10								
BOD	5.1	3.0	2.7								
Ammonia	2.4	1.9	<0.1								
Phenol(ug/l)	25	0	not Detect								

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115

TABLE 2 SHEET 4

WATER ANALYSIS RESULTS

SAMPLING LOCATION SURFACE WATER STATION SW7 TESTED BY COLLECTED AND TESTED BY REGION

Date / PARAMETER	Nov 26 1981	June 3 1982	Dec 8 1982	June 7 1983	Nov 11 1983	May 10 1984					
Conductivity(umhos/cm)		1520				900					
pH		8.22				7.6					
Chloride		19				112					
tot.Kjeldahl Nitrogen		44				0.52					
Iron		-				0.15					
BOD		2.0				40					
Ammonia		2.1				0.32					
Phenol (ug/L)		0				0					

NOTE: concentrations in p.p.m. unless otherwise noted.

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PROJECT 83-115 TABLE 3 SHEET 1

WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 REMARKS COLLECTION AND ANALYSIS BY REGION

PROPERTY		Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984					
CONDUCTIVITY μMHOS/CM.		10,000	15000	15000	10900	7500	9000					
pH		7.55	8.29	7.6	8.1	7.9	8.1					
HARDNESS ($CaCO_3$)		1250	-	1275	1300	1080	1270					
ALKALINITY ($CaCO_3$)												
CHLORIDE (Cl)		60	75	3000	28.50	3150	1750					
SULPHATES (SO_4)		300	225	5200	160	600	100					
PHOSPHOROUS AS P	Total	2.0	6.8	2.5	4.29	3.5	2.8					
	Soluble											
NITROGEN (N)	Total Kjeldahl	1200	6.43	396	540	95	11.2					
	Free Ammonia	1200	643	340	360	132.5	0.02					
	Nitrite ug/L	-	-	-	1.0	ND	2.9					
	Nitrate	-	-	7.3	1.6	-	-					
METALS	Chromium (Cr)	ND	ND	0.50	0.11	0.10	ND					
	Copper (Cu)	0.1	0.1	0.33	0.40	ND	0.04					
	Zinc (Zn)	0.1	0.2	0.28	0.11	0.16	0.10					
	Nickel (Ni)	0.3	0.3	0.24	0.23	0.17	0.12					
	Iron (Fe)	1.5	2.7	7.7	4.2	4.5	7.2					
BOD		286	696	129	119	620	560					
Total Dissolved Solids		8736	-	10108	9282	6640	6140					
COD		2132	4706	1801	96	956	941					

NOTE: concentrations in p.p.m. unless otherwise noted.

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WATER ANALYSIS RESULTS

SAMPLING LOCATION LEACHATE FROM COLLECTION SYSTEM MANHOLE #1 TESTED BY REGION

	Nov 27 1981	Jun 3 1982	Dec 8 1982	Jun 7 1983	Nov 30 1983	May 10 1984					
Dissolved Oxygen	801	-	4.5	7.1	-	2.6					
Phenol ug/L	331	156	281	80	1.38	-					
PCB ug/L	2.1	3.0	-	-	<0.004	-					
Total Coliform/100ml	5000±	800	1800	2500	-	-					
Fecal Coliform/100ml	10	100	0	45	-	-					

NOTE: concentrations in p.p.m unless otherwise noted.

TABLE 4: PCB IN SEDIMENT SAMPLE

		Oct.31 1979	Nov. 25 1980	June 3 1982	Nov.30 1983	
STATION	SW 1	No Test	0.017	0.025	0.034	
	SW 2	244	0.90	No Test	No Test	
	SW 4	662	0.39	0.024	0.018	
Soil At Borehole 2		No Test	No Test	No Test	0.023	

NOTES:

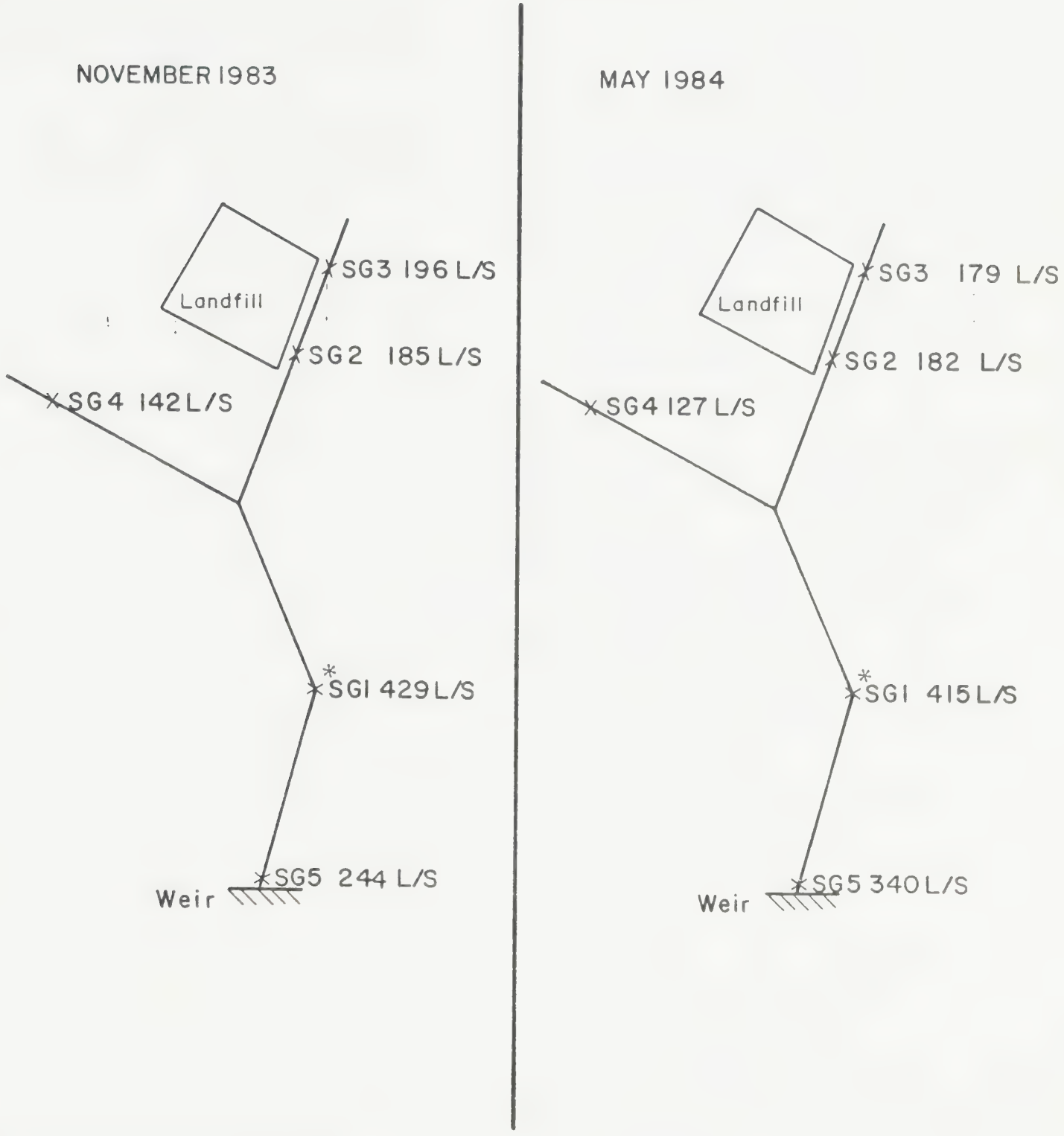
1. Concentration expressed in ug/g (microgram/gram)

2. Oct.31,1979 Analysis by Peninsula Chemical Analysis

3. Nov.25,1980 Analysis by Beak

4. June 3, 1982 and Nov.30,1983, Analysis supplied by Region

Summary of Stream Flow Gaugings



*Gauging results from SG1 (concrete flume structure) were inaccurate.

STREAMFLOW GAUGING RECORD

NOV. 1983

Gauging No. SG 1

Date: 30 Nov,1983 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 429 ~~m³/sec~~ or L/sec.

Location: Concrete channel section at pipeline crossing
Red Hill Creek

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge: _____ m

Weather: Snow Showers

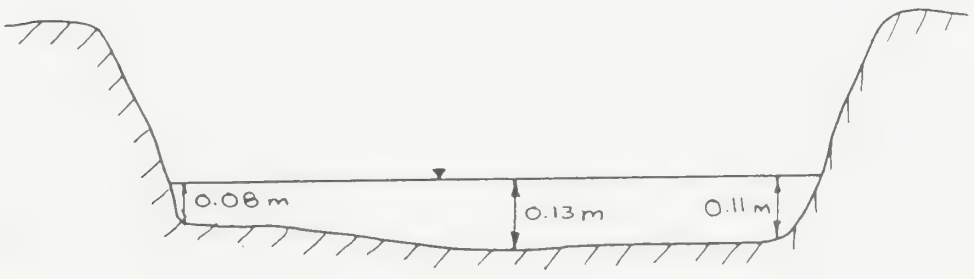
Stream Width 3.75 m. Max. Depth: 0.13 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Red Hill Creek

Description of Bottom: Concrete

Comments: Propeller was partially above water surface during gauging.

Sketch: Location - see Site Plan



Gartner Lee Associates Limited

STREAMFLOW GAUGING RECORD

Gauging No. SG 2 November 1983

Date: 30 Nov.1983 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 185 ~~xxxx/sec~~ m^3/sec or L/sec.

Location: Red Hill Creek, Eastern Limit of Landfill

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge: _____ m

Weather: Snow Showers

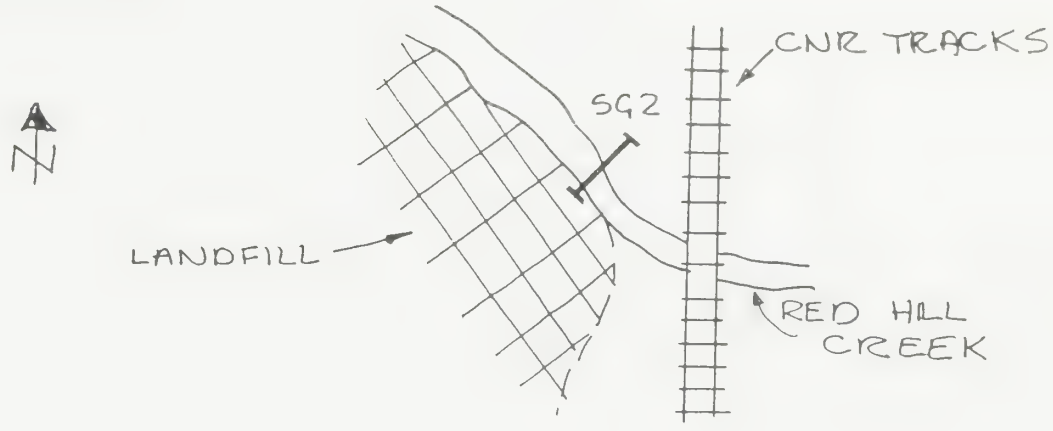
Stream Width: 2.4 m. Max. Depth: 0.17 m. Water Temp.: _____ °C

Clarity: Clear Water Source: _____

Description of Bottom: Mostly hard, stony with occasional softer spots.

Comments: _____

Sketch: Location See Figure 1.



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STREAMFLOW GAUGING RECORD

Gauging No. SG-4 November 1983

Date: 30 Nov. 1984 Project No.: 83-115 Names: J. McLean

A. Hims

Flow Rate: 142 ~~xxxxxxsec~~ m^3/sec or L/sec.

Location: Tributary to Red Hill Creek, Concrete Channel section downstream from Stone Church Road

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge: _____ m

Weather: Snow Showers

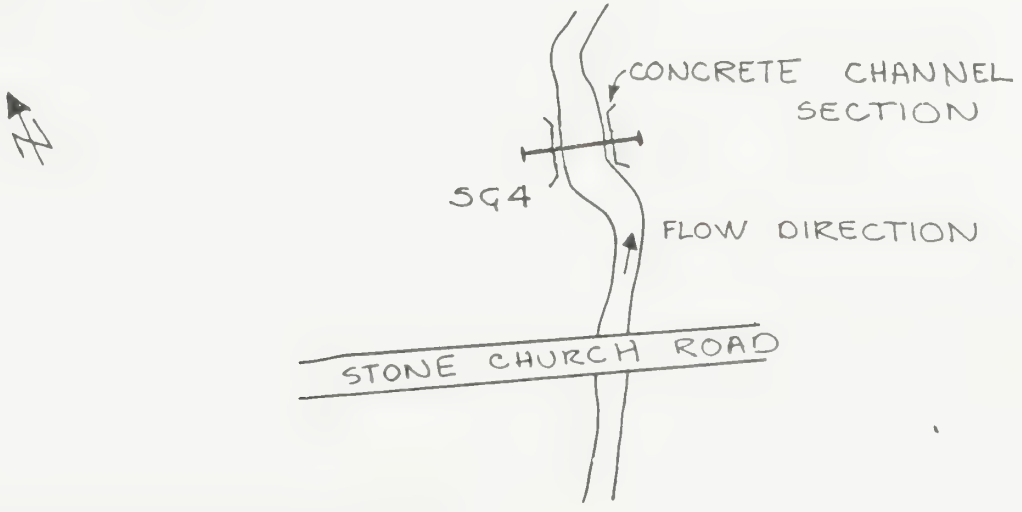
Stream Width: 1.6 m. Max. Depth: 0.25 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Tributary to Red Hill Creek

Description of Bottom: Concrete Channel

Comments: Right bank quite weedy (overhang)

Sketch: Location - See Figure 1



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STREAM FLOW ESTIMATE

SG5 at Albion Falls

November 1983

DATE: 30 November 1984 PROJECT: 83-115 NAMES: J. McLean
A.G. Hims

FLOW RATE ESTIMATE: 244 L/sec

LOCATION : Red Hill Creek Weir Outlet at Albion Falls,Mud Street

METHODOLOGY: By measuring the dimensions and configuration of the weir using a tape measure and estimating the head, the flow over the weir was estimated.

RESULTS:

L=8' b=24' H=5.7" =0.475'

$L/B = \frac{8}{24} = 0.33$ Thus $K_L = 0.008$

P=36"

$H/P = \frac{5.7}{36} = 0.16$ Thus $C_e = 3.2$

$L_e = 8 + 0.008$

$= 8.008'$

$H_e = 0.475 + 0.008$

$= 0.483$

Flow $Q = C_e L_e H_e^{3/2}$

$= 3.2 \times 8.008 \times 0.483^{3/2}$

$= 8.602$ cfs

$=$ 244 L/sec

STREAMFLOW GAUGING RECORD

Gauging No: SG 1 May 1984

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean

Flow Rate: 415 ~~xxx³/xxxx~~ or L/sec.

Location: Concrete Channel Section at Pipeline Crossing

Red Hill Creek

Meter: PYGMY Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, Breezy

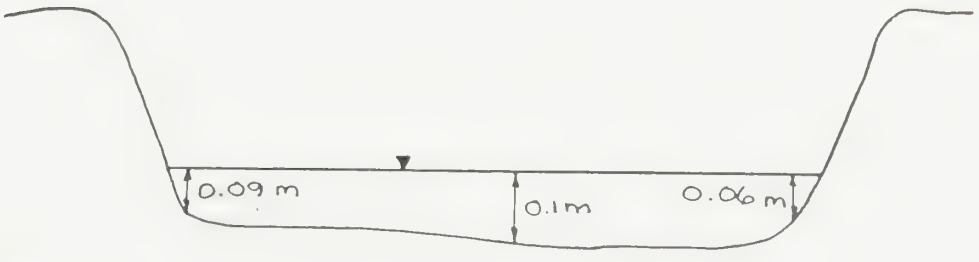
Stream Width: 3.74 m. Max. Depth: 0.1 m. Water Temp.: _____ °C

Clarity: Clear becoming very silty during gauging Water Source: _____

Description of Bottom: Concrete

Comments: Electro-mechanical counter operating too fast to ensure accuracy.

Sketch:



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STREAMFLOW GAUGING RECORD

Gauging No. SG-2

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean

Flow Rate: 182 ~~m^3/sec~~ or L/sec.

Location: Red Hill Creek, Eastern Limit of Landfill

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge _____ m

Weather: Warm, breezy

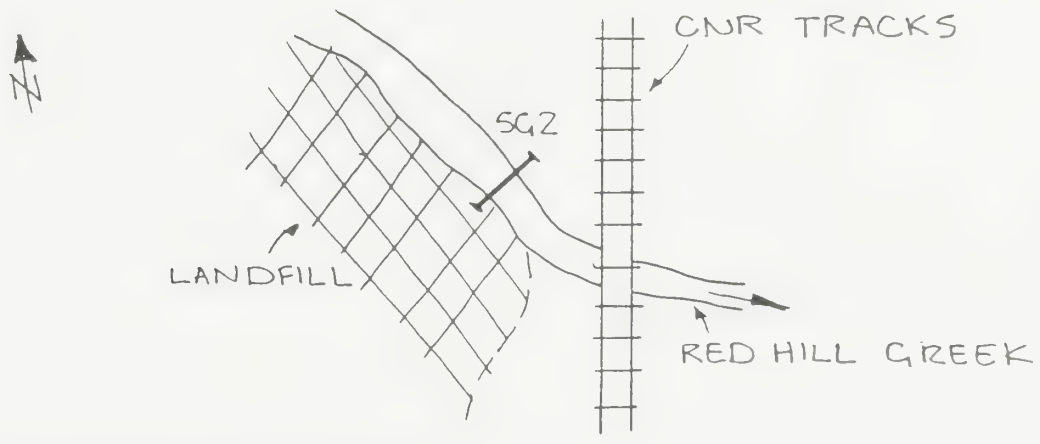
Stream Width: 2.45 m. Max. Depth: 0.19 m. Water Temp.: _____ °C

Clarity: Silty Water Source: Red Hill Creek

Description of Bottom: Mostly hard, stony with occasional softer spots.

Comments: _____

Sketch: Location see Figure 1



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STREAMFLOW GAUGING RECORD

Gauging No. SG 3 May 1984

Date: 10 May 1984 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 179 ~~m^3/sec~~ or L/sec.

Location: Red Hill Creek North End of Landfill just downstream from Bedrock exposure.

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge: _____ m

Weather: Warm, Breezy.

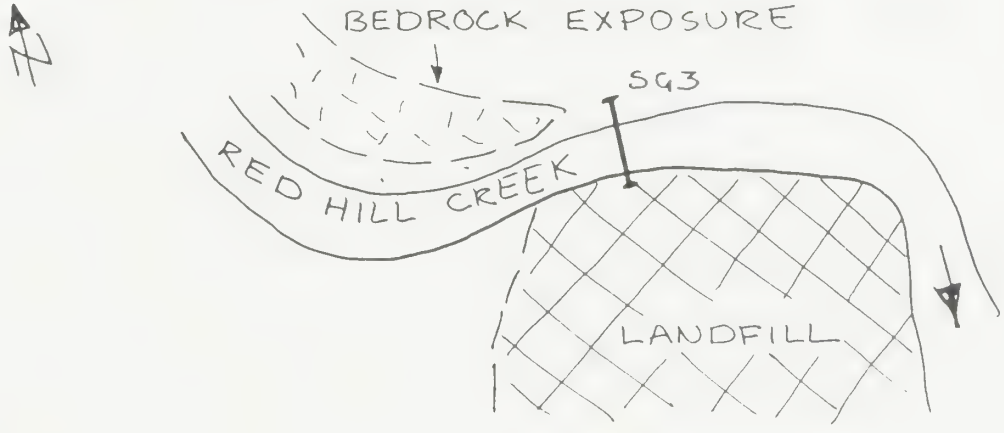
Stream Width: 3.09 m. Max. Depth: 0.28 m. Water Temp.: _____ °C

Clarity: Clear Water Source: _____

Description of Bottom: Mostly hard, some bedrock exposed.

Comments: _____

Sketch: Location see Figure 1



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STREAMFLOW GAUGING RECORD

Gauging No. SG-4

Date: 127 Project No.: 83-115 Names: J. McLean
A. Hims

Flow Rate: 127 ~~m³/sec~~ or L/sec.

Location: Tributary of Red Hill Creek, Concrete Channel section downstream from Stone Church Road

Meter: OTT Model: _____ No.: _____

Pivot/Propellor No.: _____ Staff Gauge: _____ m

Weather: Warm, breezy

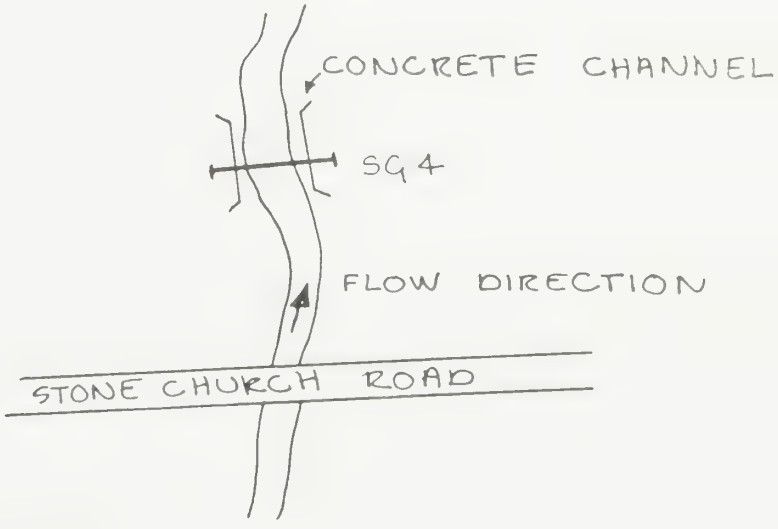
Stream Width: 1.82 m. Max. Depth: 0.28 m. Water Temp.: _____ °C

Clarity: Clear Water Source: Tributary to Red Hill Creek

Description of Bottom: Concrete

Comments: Right Bank quite weedy. (overhang)

Sketch: Location see Figure 1.



Gartner Lee Associates Limited

STREAM FLOW ESTIMATE

May 1984

SG5 at Albion Falls

DATE: 10th May, 1984 PROJECT: 83-115 NAMES: J. McLean
A.G. Hims

FLOW RATE ESTIMATE = 340 L/sec

LOCATION: Red hill Creek Weir Outlet at Albion Falls, Mud Street

METHODOLOGY: By measuring the dimensions and configuration of the weir, using a tape measure and transit, the flow at the weir was estimated.

RESULTS: Datum assumed on weir = 100'

ELEVATION SOUTH END OF WEIR = 91.18' NORTH END =91.19'

AVERAGE = 91.185'

ELEVATION OF WATER WERB = 91.77'

WELB = 91.78'

AVERAGE = 91.775

$\therefore$ HEAD ON WEIR,H. = 0.59'

LENGTH OF WEIR = 8' b=24' L/b = 0.33

P = 3'

H = 0.6' $H/P = \frac{0.6}{3} = 0.2$

$K_L = 0.008$ $K_H = 0.003$ $H_e = 0.603$

$C_e = 3.2$

Flow Q = Ce Le $He^{3/2}$ = $3.2 \times 8.008 \times 0.603^{3/2}$

= 12.0 cfs

= 340 L/sec

APPENDIX 2

GROUNDWATER CHEMISTRY

BOREHOLE LOGS #1, 4, 6, 9, 11 AND 12

TABLE 5 GROUND WATER MONITOR DETAILS

TABLE 6 GROUND WATER CHEMISTRY ANALYSIS RESULTS
BOREHOLES 1, 4, 6, 9, 11 AND 12 NOV. 1981 TO MAY 1984

LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

Standard Penetration Resistance 'N' - The number of blows required to advance a standard split spoon sampler 12 inches into the subsoil, driven by means of a 140 pound hammer falling freely a distance of 30 inches.

Dynamic Penetration Resistance - The number of blows required to advance a 2 inch, 60 degree cone, fitted to the end of drill rods, 12 inches into the subsoil, the driving energy being 350 foot pounds per blow.

DESCRIPTION OF SOIL

The consistency of cohesive soils and the relative density or denseness of cohesionless soils are described as follows:

Consistency	'N' Blows/Foot	Denseness	'N' Blows/Foot
Very Soft	0-2	Very Loose	0-4
Soft	2-4	Loose	4-10
Firm	4-8	Compact	10-30
Stiff	8-15	Dense	30-50
Very Stiff	15-30	Very Dense	> -50
Hard	> 30		

W.T.P.L.	-	Wetter than Plastic Limit
D.T.P.L.	-	Drier than Plastic Limit
A.P.L.	-	About Plastic Limit

DESCRIPTION OF ROCK

$$\% \text{ Recovery} = \frac{\text{Total Length of Core Recovered/Run}}{\text{Total Length of Drilling Run}} \times 100$$

TYPE OF SAMPLE

SS	-	Split Spoon
AS	-	Auger Sample
NX	-	2.16" ϕ Rock Core
▲	-	Water Table Monitor (Standpipe Tip)
●	-	Piezometer Tip

BOREHOLE NO. 1

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 6, 1979

BOREHOLE TYPE BOA 3¼ I.D. HOLLOW STEM AUGERS, 4" TRICONE NX CORE — GEOLOGIST A.B.

ELEVATION 655.4 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		Topsoil						
		TILL: Medium brown clayey silt till, moist						
10.0		DOLOSTONE: Medium grey, medium crystalline, thin to thick bedded dolostone, - very cherty - shaly from 31.7' to 35.0'	NX			100	▲	Goat Island to 25' 4" Tricone to 25'0 Gasport 25-31.7' followed by Decew/ Rochester
37.5		Borehole terminated at 37.5 in dolostone	NX			100	●	

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. 4

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 20, 1979

BOREHOLE TYPE BOA, 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 674.2 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		GARBAGE						
54.0		DOLOSTONE Medium grey dolostone - cherty					▲	Goat Island

● Piezometer Tip ▲ Standpipe Tip

BOREHOLE NO. 4 (cont'd)

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 20, 1979

BOREHOLE TYPE BOA, 3¼" HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION _____ — TECHNOLOGIST _____

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
90.0		DOLOSTONE - continued						
105.0		Borehole terminated at 105.0' in dolostone.						

● Piezometer Tip ▲ Standpipe Tip

BOREHOLE NO. 6

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 24, 1979

BOREHOLE TYPE BOA, 3¼" I.D. HOLLOW STEM AUGERS, NX CORE — GEOLOGIST A.B.

ELEVATION 648.8 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.5		TOPSOIL						
		TILL: Medium brown clayey silt till, moist						
5.0		LACUSTRINE CLAYEY SILT: Medium brown clayey silt becoming grey and saturated at ± 15'.					▲	
49.0								
50.0		SAND AND GRAVEL						
		DOLOSTONE: Medium grey, fine crystalline, medium to thick bedded dolostone, cherty minor sphalerite						Goat Island
76.0								
		Borehole terminated at 78.0' in dolostone.						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. 9

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE SEPT. 11, 12, 1979

BOREHOLE TYPE BOA 3¼" HOLLOW STEM AUGERS, 3" &4" TRICONES — GEOLOGIST A.B.

ELEVATION 596.2 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		TOPSOIL						
		LACUSTRINE CLAYEY SILT						
5.0		Medium brown clayey silt, moist						
		DOLOSTONE						
		Medium grey dolostone - cherty					▲	Goat Island Dolomite (Ancaster Chert beds)
32.0							●	
		Borehole terminated at 32.0' in dolostone.					●	

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. 12

PROJECT NAME SUPPLEMENT BOREHOLE - UPPER OTTAWA ST. LANDFILL
PROJECT NO. 80-180
CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
DATE November 12, 1980
BOREHOLE TYPE BOA, 3" TRICONE, NX ROCK CORE
GEOLOGIST A.B.
ELEVATION
TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		TOPSOIL					▲	Goat Island to 17.0', followed by Gasport
2.0		TILL Medium brown clayey silt till, moist						
		DOLOSTONE Medium grey, fine to medium crystalline, thin bedded dolostone						
19.0							●	

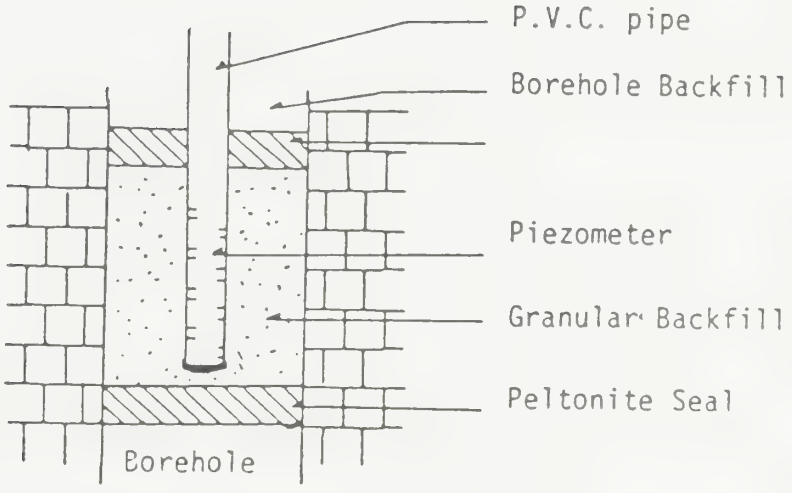
● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

GROUND WATER MONITOR DETAILS

INSTALLATION DETAILS

A. PIEZOMETER: The piezometer consists of an 18 inch long slotted pipe 1¼ inches in diameter. Piezometers are used to measure the hydrostatic pressure, to obtain ground water samples and to measure in situ permeability.



TYPICAL INSTALLATION

B. STANDPIPE: Standpipes consist of P.V.C. or C.P.V.C. pipe with the bottom 10 feet of each standpipe slotted every 1.0 foot. Standpipes are used to measure the ground water table and to obtain ground water samples.

GROUND WATER MONITOR DETAILS *

Table 5

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter (in.)	Type	Elev. (a.s.l)	Depth (ft.)	Elev. (asl)	Depth (ft)	Elev (a s l)
1	1	1¼	●	656.4 (ft)	37.5	618.9(ft)	35.0	621.4 (ft.)
	11	½	CPVC ▲	656.4	20.0	636.4	20.0, 9.0,3.0	636.4,647.4 653.4
2	1	1¼	●	673.4	73.0	600.4	70.0,3.0	603.4,670.4
	11	1¼	▲	673.9	75.0	598.9	65.0,2.0	608.9,671.9
3	1	1¼	●	676.4	103.8	572.6	100.3,1.3	576.1,675.1
	11	1¼	▲	676.9	80.0	596.9	69.0,2.0	607.9,674.9
	111	1¼	▲	678.5	43.5	635.0	22.5	656.0
	1111	1¼	▲	678.5	22.5	656.0	2.5	676.0
4	1	1¼	●	675.0	99.8	575.2	93.8,1.8	581.2,673.2
	11	1¼	▲	675.2	85.5	589.7	75.0,2.0	600.2,673.2
5	1	1¼	●	657.0	79.0	578.0	75.0	582.0
	11	½	●	657.0	58.5	598.5	58.5,54.0	598.5,603.0
	111	½	▲	657.0	54.0	603.0	43.0,3.0	614.0,654.0
6	1	1¼	●	650.8	77.0	573.8	74.0	576.8
	11	½	●	650.8	67.0	583.8	67.0,63.0	583.8,587.8
	111	½	▲	650.8	50.0	600.8	50.0,38.0,3.0	600.8,612.8, 647.8
7	1	1¼	●	647.1	46.0	601.1	42.5	604.6
	11	½	●	647.1	25.5	621.6	25.5,21.5	621.6,625.6
	111	½	▲	647.1	19.5	627.6	19.5,8.5,2.5	627.6,644.6, 638.6
8	1	1¼	●	621.9	69.6	552.3	66.0	555.9
	11	½	CPVC ●	621.7	48.3	573.4	48.3,44.0	573.4,577.7
	111	½	CPVC ▲	621.9	24.2	597.7	24.2,13.0,1.0	597.7,608.9, 620.9
9	1	1¼	●	598.2	34.0	564.2	31.0	567.2
	11	½	●	598.1	21.9	576.2	21.9,19.9	576.2,578.2
	111	½	▲	598.1	19.9	578.2	8.9,2.9	589.2,595.2
10	1	1¼	●	596.4	42.0	555.3	39.0	558.3
	11	½	●	596.5	20.0	577.3	20.0,18.0	577.3,579.3
	111	½		596.5	18.0	579.3	7.0,4.0	590.3,593.3
11	1	1¼	●	602.6	53.0	549.6	59.0,	543.6
	11	3/4	●	602.6	22.0	580.6	22.0,17.0	580.6,585.6
	111	½	▲	602.5	10.0	592.5	3.0	599.5
12	1	1¼	●	N/A	19.0		17.0	
	11	3/4	▲	N/A	13.0		2.0	
G.M.1	1	½	▲	615.8	39.0	576.8	3.5	612.3
G.M.2	1	½	▲	622.2	39.0	583.2	2.5	619.7
G.M.3	1	½	▲	636.6	24.5	612.1	2.5	634.1
G.M.4	1	½	▲	636.6	24.5	612.1	2.5	634.1

● - Piezometer ▲ - Standpipe

Gartner Lee Associates Limited

* All measurements taken from the top of each monitor

GROUND WATER MONITOR DETAILS

Table 5

BOREHOLE NO.	MONITOR				LOCATION OF TIP		LOCATION OF SEAL	
	No.	Diameter(in.)	Type	Elev.(a.s.l)	Depth(ft)	Elev.(a.s.l)	Depth(ft)	Elev.(a.s.l)
G.M.5	1	½	▲	648.1(ft.)	22.0	626.1(ft)	5.0	643.1(ft.)
G.M.6	1	½	▲	650.5	22.0	628.5	5.0	645.5
G.M.7	1	3/4	▲	650.4	18.0	632.4	3.0	647.4
G.M.8	1	3/4	▲	N/A	18.0	N/A	1.5	N/A
G.M.9	1	3/4	▲	N/A	19.5	N/A	2.0	N/A

● - Piezometer ▲ - Standpipe

TABLE: 6

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH1-I

SHEET: 1

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	2800	9000	6500	1100	3000	11000
pH	6.9	7.7	6.9	6.75	7.2	7.3
Hardness	1700	238	1275	1320	1140	2010
Alkalinity	380	334	255	244	280	245
Chloride	140	2500	1983	5400	900	4050
Tot. Kjeldahl	700	710	0.86	1.34	0.08	0.76
Calcium	350	117	375	960	130	700
Free Ammonia	600	7.85	0.30	<.10	0.08	0.04
Nitrate	*	*	5.0	0.19	ND	0.4
Nitrite ug/L	*	*	4.0	2.6	74	6.0
Phenol ug/l	0	0.20	3.07	156	0.08	0
BOD	86	156	5.7	NO	11	20
COD	220	294	118	341	29	397
Sulphate	9773	2750	8750	625	685	950
Phosphate	-	-	-	-	-	-
Phosphorous	0.24	0.10	0.15	0.39	0.01	0.05
PCB ug/l						<0.04
Chromium	ND	ND	0.21	0.04	0.04	ND
Copper	0.2	1.2	0.18	0.06	ND	0.05
Iron	1.4	0.5	4.9	2.20	0.40	<.10
Nickel	<.1	ND	<110	0.08	ND	<.10
Zinc	<1	0.03	0.10	2.78	0.02	ND
Tot. Coliform	70	50	0	270		
Fecal Coliform	10	0	0	0		
Sodium	420	2050	1035	3230	550	2320

TABLE: 6
SHEET: 2

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 4-I

Note: All test results expressed in mg/l, unless otherwise indicated.

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	14000	13200				
pH	7.7	7.88				
Hardness	700	309				
Alkalinity	6580	308				
Chloride	60	400				
Tot. Kjeldahl	1600	697				
Calcium	35	30				
Sodium	3300	1950				
Free Ammonia	1500	499.8				
Nitrate	*	*	Not Available	Not Available	Not Available	Not Available
Nitrite	*	*				
Phenol ug/l	1579	26				
BOD	986	218				
COD	4706	3162				
Sulphate	600	975				
Phosphate	-	-				
Phosphorous	6.0+	4.3				
PCB						
Chromium	ND	ND				
Copper	3.0	7.2				
Iron	5.5	6.4				
Nickel	0.3	0.3				
Zinc	0.4	0.07				
Tot. Coliform	0	900				
Fecal Coliform	0	80				

* Strong colour, prevented analysis
+ Result unreliable, probably high

TABLE: 6

SHEET: 5

UPPER OTTAWA STREET

TEST SET GROUP G-B

GROUND WATER MONITOR BH 11-I

NOTE: All test results expressed in mg/l, unless otherwise indicated

PARAMETERS	811127	820603	821208	830607	831130	840510
Conductivity	12000	11800	20500	13500	15000	26000
pH	6.5	7.8	6.8	6.9	6.9	7.5
Hardness	5360	393	7358	8600	6150	10000
Alkalinity	260	304	300	324	170	279
Chloride	5570	3650	8305	7600	7750	12300
tot.Kjeldahl	4.60	21	5.7	6	5.2	7.2
Calcium	900	875	2170	4400	1900	2670
Sodium	2000	1500	2380	3800	2700	4000
Free Ammonia	1.50	28.6	5.6	6	2.6	60
Nitrate	*	*	<0.1	0.55	ND	1.1
Nitrite ug/l	*	*	6.0	2.6	*	*
Phenol ug/l	7	18	ND	102	ND	0
BOD	123	125	147	126	124	140
COD	625	809	882	515	794	1118
Sulphate	1652	1275	46400	540	1800	1000
Phosphate						
Phosphorous	ND	0.21	0.04	0.13	0.02	0.06
PCB ug/l						<0.04
Chromium	ND	ND	0.40	0.15	0.05	ND
Copper	<.1	1.3	0.13	0.04	ND	0.04
Iron	0.1	1.1	0.53	0.21	0.46	0.25
Nickel	0.2	ND	0.10	0.12	0.12	0.12
Zinc	ND	0.05	0.11	0.04	0.04	0.05
tot. Coliform	10	7600	0	11		
Fecal Coliform	0	30	0	0		

* strong colour, prevented analysis

APPENDIX 3 - COMBUSTIBLE GAS

Gas Monitor Boreholes GM1 to GM9

Table 7 % CombustibTe Gas Results - April 1982 to June 1984.

BOREHOLE NO. G.M. 1

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 10, 11, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 614.3 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0		LACUSTRINE CLAYEY SILT Medium brown lacustrine clayey silt, moist -turning grey 18.0'						
26.0		DOLOSTONE Medium grey dolostone -cherty						
38.0		Borehole terminated at 38.0' in dolostone					▲	½" Gas monitor installation

● Piezometer Tip ▲ Standpipe Tip

BOREHOLE NO. G.M. 2

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE
PROJECT NO. 79-78
CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH
DATE Sept. 10, 11, 1979
BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE
GEOLOGIST A.B.
ELEVATION 621.7
TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		LACUSTRINE CLAYEY SILT Medium brown lacustrine clayey silt, moist						
18.0								
		SAND AND GRAVEL Medium brown sand and gravel						
25.0								
		DOLOSTONE Medium grey dolostone -cherty						
39.0							▲	½" Gas monitor installation
		Borehole terminated at 39.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 3

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 11, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 636.1 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		TILL Medium brown clayey silt till, moist						
8.0								
		SAND AND GRAVEL Medium brown sand and gravel saturated						
13.0								
		DOLOSTONE Medium to dark grey dolostone -shaly						
25.0							▲	½" Gas monitor installation
		Borehole terminated at 25.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 5

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 13, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 645.1 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		FILL Medium brown clay silt, boulders, concrete, moist						
6.0								
		DOLOSTONE Medium grey dolostone -cherty						
19.0							▲	½" Gas Monitor installation
		Borehole terminated at 19.0' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 6

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE Sept. 14, 1979

BOREHOLE TYPE BOA 3¼" I.D. HOLLOW STEM AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 647.5 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		FILL Medium brown clayey silt, boulders, concrete, moist						
4.0		DOLOSTONE Medium grey dolomite -cherty						
19.0		Borehole terminated at 19.0' in dolostone					▲	½" Gas Monitor installation

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. G.M. 7

PROJECT NAME UPPER OTTAWA STREET LANDFILL SITE — PROJECT NO. 79-78

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH — DATE March 4, 1980

BOREHOLE TYPE BOA 3¼" I.D. AUGERS, 3" TRICONE — GEOLOGIST A.B.

ELEVATION 648.4 — TECHNOLOGIST

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
		FILL Mixture of sand, clay, silt, stones, moist						
4.0		DOLOSTONE Medium grey cherty dolostone						
							▲	3/4" Gas Monitor installation
17.5								
		Borehole terminated at 17.5' in dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. GM 8

PROJECT NAME SUPPLEMENT GAS MONITOR - UPPER OTTAWA ST. LANDFILL PROJECT NO. 80-181

CLIENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH DATE November 10, 1980

BOREHOLE TYPE BOA, 3" TRICONE, NX CORE GEOLOGIST A.B.

ELEVATION _____ TECHNOLOGIST _____

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.0								
1.5		FILL Sand and gravel, moist						
		DOLOSTONE Medium grey, fine crystalline, thin bedded dolomite porous from 5.0'	NX			60		Goat Island to 5.0' Gasport 5.0' to 9.5' Decew-Rochester from 9.5'
9.5								
		SHALY-DOLOSTONE Dark grey, fine crystalline, thin bedded shaly-dolostone	NX			65		
18.0							▲	
		Borehole terminated at 18.0' in shaly-dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

BOREHOLE NO. GM 9

PROJECT NAME SUPPLEMENT GAS MONITOR - UPPER OTTAWA ST. LANDFILL PROJECT NO. 80-181

CLIENT REGIONAL MUNICIPALITY OF HAMILTON - WENTWORTH DATE November 10, 11, 1980

BOREHOLE TYPE BOA, 3¼" I.D. AUGERS, 3" TRICONE, NX CORE GEOLOGIST A.B.

ELEVATION _____ TECHNOLOGIST _____

DEPTH	STRATIGRAPHY	DESCRIPTION	SAMPLE TYPE	SAMPLE BLOWS/FT	SAMPLE M/C	SAMPLE %RECOVERY	GROUND WATER	REMARKS
0.6		~~TOPSOIL~~						
4.7		TILL Medium brown clayey silt till, moist	NX			70		Goat Island to 8.0' Gasport form 8.0' to 15.0' followed by Decew-Rochester
15.0		DOLOSTONE Medium grey, medium crystalline, thin to thick bedded, dolostone	NX			60		
20.0		SHALY-DOLOSTONE Dark grey, fine crystalline, thin bedded, shaly dolostone					▲	
		Borehole terminated at 20.0' in shaly - dolostone						

● Piezometer Tip ▲ Standpipe Tip

Gartner Lee Associates Limited

PROJECT 83-115 % COMBUSTIBLE TABLE 7 SHEET 1

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

Date / MONITOR	Apr 22 1982	Oct 27 1982	Dec 12 1982	Apr 20 1983	June 15 1983	Aug 25 1983	Oct 26 1983	Jan 26 1984	Feb 24 1984	Mar 27 1984	Apr 27 1984
GM 1	0	0	0	0	0	0	0	0	0	0	0
GM 2	-	-	0	0	0	0	0	0	0	0	0
GM 3	-	-	0	0	0	0	0	0	0.5	0	0
GM 4	0	0	0	0	0	0	0	0	0	0	0
GM 5	0	0	0	0	0	0	0	0	0	0	0
GM 6	0	0	0	0	0	0	0	0	0	0	0
GM 7	0	0	0	0	0	0	0	0	0	0	0
GM 8	0	0	0	0	0	0	D	E S	T R	O Y	E D
GM 9	0	0	0	0	0	0	0	0	0	0	0
Quonset Hut	-	-	4	5+	5+	-	0	0	0	0	0

NOTE: concentrations in p.p.m. unless otherwise noted.

Gartner Lee Associates Limited

PROJECT 83-115 % COMBUSTIBLE GAS TABLE 7 SHEET 2

SAMPLING LOCATION UPPER OTTAWA STREET LANDFILL TESTED BY REGION OF HAMILTON WENTWORTH

Date / MONITOR	June 27 1984										
GM 1	0										
GM 2	0										
GM 3	0										
GM 4	0										
GM 5	0										
GM 6	0										
GM 7	0										
GM 8	Destroyed										
GM 9	0										
Quonset Hut	0										

NOTE: concentrations in p.p.m. unless otherwise noted.

APPENDIX 4 - SITE PLAN

LEGEND

- STREAM GAUGING AND SURFACE WATER SAMPLING LOCATION
- GAS MONITORING LOCATION
- VEGETATION STRESS / KILL
- SURFACE EROSION
- LEACHATE SEEPAGE
- ERODED DRAINAGE CHANNEL

UPPER OTTAWA STREET LANDFILL

ANNUAL MONITORING REPORT

REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

LANDFILL SITE CONDITION

PROJECT No. 461-851 | MAY 1986

morrison beatty limited consulting engineers and hydrogeologists

1

UPPER OTTAWA STREET

SERVICE ROAD

SW 4

M.S.#2B

M.S.#9G

M.S.#7G

M.S.#8G

M.S.#6G

M.S.#5G

M.S.#4G

M.S.#3G

M.S.#3B

M.S.#6B

M.S.#8B

M.S.#2G

M.S.#1G

SW 2

CREEK

SLOPE STABILIZATION WITH FABRIFORM

CULVERT

FIRE DEPARTMENT TRAINING CENTRE

EXIST. SURFACE WATER DITCH

LEACHATE COLLECTION TOE DRAIN SYSTEM

PUMPING WELL

CULVERT

FORCEMAIN SEWER

GRAVITY FLOW SECTION

EXIST. SANITARY SEW.

EXIST. STORM SEW.

STONE CHURCH ROAD

CANADIAN NATIONAL RAILWAY

MH

C.O.

NOTE:
M.S. - MONITORING STATION

UPPER OTTAWA STREET - LANDFILL SITE

SITE CLOSURE PROCEDURES

DRAWING No. 81-S-7 | SHEET 1A OF

THE REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH

DEPARTMENT OF ENGINEERING

DATE: 81-03-20 | PROJECT No. E309-01A

APPROVED

COMMISSIONER OF ENGINEERING

DIRECTOR

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